FAMILIAR LESSONS

ON

FOOD AND NUTRITION

T. TWINING.

FAMILIAR LESSONS

ON

FOOD AND NUTRITION;

INTENDED TO SERVE AS A

HANDBOOK TO THE FOOD DEPARTMENT

OF THE

PARKES MUSEUM OF HYGIENE,

AND TO FORM ONE OF THE PROPOSED SEQUELS TO
THE COURSE OF ELEMENTARY LECTURES,

ENTITLED,

"SCIENCE MADE EASY."

BY

THOMAS TWINING,

AUTHOR OF "TECHNICAL TRAINING," "SCIENCE MADE EASY," ETC.

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Introduction.

PURPOSE AND PLAN.

If there is any one Science which can dispense with praise, it is Hygiene, the Science of Health, which propounds to the world the most acceptable doctrine that human wisdom can impart, teaching how to live a long life, and really to enjoy it. To render this instruction more clear and impressive by means of illustrations of every kind, is the purpose of the Museum of Hygiene, provisionally located at University College, London. An influential Committee, got together by the exertions of Dr. G. V. Poore, recognised that such an institution would be the most appropriate memorial to the late lamented Dr. Parkes, Professor of Hygiene at the Army Medical School, Netley, and on June 28th, 1879, it was inaugurated with the most encouraging support, and under the special patronage of H.M. the Queen, at the College where that eminent Sanitarian had prepared himself for his short, but highly useful career. Embracing the whole of the subjects included in his important "Manual of Practical Hygiene," it shows how local causes of insalubrity can be removed by engineering works on a large scale, and how on a small scale, the unhealthiness of Dwellings can be remedied by sanitary

contrivances; how all the most essential attributes of a comfortable Home may be united with less expenditure than is often wasted on elegant discomfort, and how the precepts of Domestic Hygiene should be followed up by those of Personal Hygiene, which embodies the rationale of Food, Clothing, Cleanliness, Bodily Exercise and Mental Recreation.*

No one who appreciates the power of Science to create and to improve, can view without satisfaction the development of an Institution so well calculated to bring that power to bear on the welfare of the Million. But for me it is fraught with a more lively interest, to the origin of which I must devote a few words, as they will explain in some measure the Classification which has been adopted, and the flattering manner in which I have been allowed to take charge of the Food Department in particular, both as regards contributing materials, and as regards supplying means for displaying them.

The Museum of Domestic and Sanitary Economy, better known under the title of the Twickenham Economic Museum, was before its destruction by fire in 1871, a Hygienic Museum *plus* an assortment of those things, which, without having a direct bearing on Health, have become almost indispensable requisites of civilized life. Such are for instance the pens, ink, and paper that minister to our intellectual wants, the appliances by which we measure time and space, bulk and weight; to say nothing of various matters connected with the construction, decoration, and furnishing

* A comprehensive Programme of Classification has been prepared with the sanction of the Executive Committee, and may be obtained free on application to Mark H. Judge, Esq., Parkes Museum, University College, London, or to William Hudson, Esq., B. Sc., Economic Museum, Twickenham.

of Dwellings, in respect of which, after Hygiene has had her say, it is well to listen to the suggestions of Comfort and Convenience, Artistic Taste and Comparative Price. In thus embracing all the material requirements of Daily Life, one need extend but little the boundaries of a Museum of Hygiene. There is scarcely any difference to be made in the classification, and none at all in the preliminary studies required on the part of the intelligent visitor. Domestic Economy and Hygiene are at one in demanding of him a knowledge of the fundamental facts and principles of Physics and Chemistry, a little insight into Natural History, and a familiar acquaintance with Human Physiology. Accordingly the Course of ten Lectures embracing this range of subjects, under the title of "Science made Easy," which I devised as a preparatory training for the Working Men who used to come to my Economic Museum, represents just about the minimum of elementary scientific preparation, which may enable a visitor to the Parkes Museum to inspect it with real benefit and satisfaction.*

* To the "Introduction" forming the first of the Six Parts in which the Course has been published, (David Bogue, 3 St. Martin's Place, Trafalgar Square,) I may refer:—for an account of the Economic Movement originated at the Society of Arts in 1852, inaugurated at Paris in 1855, and intended to propagate among all classes of the People, sound notions of Hygiene and Domestic Economy; for a description of the Twickenham Economic Museum; for an explanation of the Binary Plan of delivery, by means of which it has become possible to circulate from that Museum, identical Lectures to the various London Institutions for popular improvement; for details of the open-handed system of Examinations, devised for testing the results obtained; lastly and especially, for an analysis of the motives which have guided me in the selection and arrangement of the subject matter of "Science made Easy," and in the publication of its Pictorial Illustrations.

It is not however always easy for the unaccustomed mind to perceive the links which connect elementary science with its applications, and it is obvious that the amateur student, who wishes to turn to the best account the knowledge acquired from the Course in question, or any equivalent source, in surveying the hygienic treasures accumulated in the Parkes Museum, will be glad to have the company of a competent *cicerone.* In the absence of one, he should be provided with a special *vade-mecum* or Hand-book, not only pointing out each object that deserves special notice, and communicating in a colloquial form whatever interesting facts and considerations are connected with it, but giving as far as possible the rationale of what is seen. With such a handbook, our visitor will make himself his own demonstrator, and attaining as he proceeds to higher knowledge, and more expanded views, he will acquire a grateful appreciation of the resources which Nature prepares and Science elaborates.

To afford assistance of this description for reviewing the Food Department, which forms Class V. of the Museum, is the purpose of the present work, in which I have made considerable use of materials committed to paper in connection with the corresponding department of my former Economic Museum.

Lectures V. and VI. of the "Science made Easy" Course, which contain the outlines of Inorganic and Organic Chemistry, and Lectures IX. and X. devoted to Physiology, may be considered as the groundwork of the present volume. The development of the latter subject will I think be found amply sufficient. As regards Chemistry, a rather more advanced knowledge would be desirable for deriving full benefit from the information contained in the Notes, Tablets and Appendices. But as for the Text, I have avoided all unnecessary technicali-

ties, giving the popular equivalents of terms too recent, or too technical, to have attained general circulation ; for the precepts of Hygiene must be made easy and familiar if they are to benefit the Million. Fortunately in the great majority of the works, not exclusively chemical, which supply hygienic materials, such as Parkes, Pavy, Johnston, Church, Edward Smith, Motard, and Lévy, the terms mainly used are not those of the most recent Manuals of Chemistry, but rather those current in the popular interpretation of chemical science. Thus in reading about springs of Hard Water, we are not told that Calcic Carbonate is rendered soluble by an excess of Carbon Dioxide, but that Carbonate of Lime is rendered soluble by an excess of Carbonic Acid, and similarly we find, not Hydric Sodic Carbonate, but Bicarbonate of Soda, prescribed for the production of Soda Water. In Organic Chemistry, the uncouthness of lengthy names recently introduced in order to illustrate intricacies of composition, renders still more necessary the resort, where possible, to their popular predecessors, ignoring the right of Sugar to be a di-glucosic Alcohol, and that of Starch to be the Oxygen Ether of a polyglucosic Alcohol of a higher order.

It may seem that the descriptive portion of this Handbook, that intended to explain seriatim the specimens methodically arranged in the Food Department of the Museum, is the portion most urgently needed, and which ought to be published first ; but there is a great deal of preliminary information which must be acquired by the visitor before he begins the round of the Stands, if his inspection is to prove thoroughly interesting and instructive. It is indispensable that he should have some notion of the distinct functions exercised in our system by distinct kinds of Food, and that he should be

in possession of the keys which Chemistry supplies for opening these mysteries, and bringing to light their hidden rationale. Thus one is led to examine successively the leading CONSTITUENTS which give character and purpose to the various alimentary products supplied by the Animal and Vegetable Kingdoms. The Mineral World brings next to the front its subsidiary resources, among which Salt abounds in points of interest, and Water in particular, claims paramount attention through its ubiquitousness, and its power as a vehicle for good and for evil.—But besides these tangible elements of Alimentation, there are certain considerations of a general character, which it is extremely useful to discuss before venturing on any detailed examination of the actual Food-stuffs. There are very few of these alimentary products but are subject to, or even actually produced by, one or more of the marvellous changes wrought by the magic of nature, and called *Fermentations*. The last of these changes is one essentially destructive of food articles, and which it is therefore extremely important to be able to prevent. Hence the interest which attaches to the various devices for the *Preservation of Food*, some of them so successful as to have established a new alliance between agriculture and navigation, by which the latter agrees to deliver to our markets fresh meat from the antipodes. Nor is this by any means the only direction in which the march of scientific progress has benefited our alimentary status. That there was *danger* lurking in the pot was long known, but it was reserved for modern savants to point out distinctly its nature, and in most cases to supply a remedy. On the other hand, it is but too true that knowledge is a two-edged weapon, which, wielded by some to our incalculable benefit, is unhappily turned by others to purposes of mischief. *Adulteration* and *Fraud* are rife, and must be

looked into before entering on the last of our preliminary subjects, namely, *Culinary Processes.*

It is to the preliminary topics thus briefly foreshadowed, that the present volume is devoted. Where-ever visual illustration is available, it is resorted to, and references in the text, thus (×), point to specimens appropriately displayed in the Museum; but by far the greater portion of the subject-matter is suited for home reading.

It is reserved for Part II. to take the visitor by the hand, and conduct him along the several Stands, bringing to bear the knowledge acquired, on the methodically arranged alimentary contributions of the Animal and Vegetable Kingdoms. After this *vade-mecum* portion of the work, the reader will still have a chapter before him on that branch of elementary Hygiene which summarizes, and deduces to a satisfactory issue, the practical information obtained, namely *Dietetics*, or the Science of Dietaries.

It is to be hoped that in time each Department of the Parkes Museum will have its appropriate Hand-book; the whole series forming a complete and methodical Manual of Hygiene. Meanwhile much useful information may be derived from the illustrated Official Catalogue, of which new editions are published from time to time.

I cannot conclude these preliminary remarks without a grateful acknowledgment of the valuable assistance afforded me by my Secretary and Librarian, William Hudson, Esq., B.Sc., whose knowledge of scientific literature has enabled me to collate the best authorities on each subject to be treated of, in a manner which the weakness of my eyes would otherwise have rendered impossible.

WORKS OF REFERENCE.

The following have been chiefly consulted in connection with this Handbook, or may be referred to in following out the subjects which it is intended to comprise. The publishers are well known London firms.

A. *Chemical.*

A Handbook of Modern Chemistry by Dr. C. M. Tidy. Price 16/-. (Churchills.)

Chemistry, Inorganic and Organic, by C. L. Bloxam. Price 16/-. (Churchills.)

Fownes' Manual of Chemistry, edited by Henry Watts. (Churchills.)

Vol. I. Physical and Inorganic Chemistry. Price 8/6.
Vol. II. Organic Chemistry. Price 10/-.

The Elements of Chemistry by William Allen Miller. (Longmans.)

Part II. Inorganic Chemistry. Price 24/-.
Part III. Organic Chemistry. Section 1. Price 31/6.

A Treatise on Chemistry by Profs. Roscoe and Schorlemmer. (Macmillan.)

Vol. I. Non-metallic Elements. Price 21/-.
Vol. II. The Metals; in 2 parts, price 18/- each.
Vol. III. Organic Chemistry.

Animal Chemistry by C. T. Kingzett. Price 18/-. (Longmans.)

Text Book of the Physiological Chemistry of the Animal Body by Arthur Gamgee. Vol. I. Price 18/- (Macmillan.)

B. *Botanical.*

Text Book of Structural and Physiological Botany by Dr. Otto Thomé, translated and edited by Alfred W. Bennett. Price 6/-. (Longmans.)

Vegetable Physiology and Systematic Botany by Dr. W. B. Carpenter. Price 6/-. (Bohn's Scientific Library.)

A Manual of Botany by Prof. Bentley. Price 14/-. (Churchills.)

The Vegetable Kingdom by Robert Hogg. Price 7/6. (Kent and Co.) Abounds in economic information.

The Vegetable Kingdom by Prof. Lindley. Price 25/-. (Bradbury & Evans.)

Profitable Plants by T. C. Archer. Price 5/-. (Routledge.) A description of the botanical and commercial characters of the principal articles of vegetable origin used for Food, &c.

Economic Products from the Vegetable Kingdom. Price 1/6. (Bogue.)

C. *Zoological.*

Zoology by Dr. W. B. Carpenter. Two vols. each 6/-. (Bohn's Scientific Library.)

A Manual of Zoology by H. A. Nicholson. Price 14/-. (Blackwood.)

Illustrated Natural History by the Rev. J. G. Wood. 3 vols. Price 42/-. (Routledge.)

The Popular Natural History by Rev. J. G. Wood. Price 7/6. (Routledge.)

For other popular Zoological Works see the Catalogue of George Routledge & Sons.

D. *Physiological.*

Lessons in Elementary Physiology by Prof. Huxley. Price 4/6. (Macmillan.)

Animal Physiology by Dr. W. B. Carpenter. Price 6/-. (Bohn's Scientific Library.)

Handbook of Physiology by W. S. Kirkes, edited by W. M. Baker. Price 12/6. (Walton.)

Treatise on Human Physiology by J. C. Dalton. Price 20/-. (Churchills.)

A Text Book of Physiology by Michael Foster. Price 21/-. (Macmillan.)

Principles of Human Physiology by Dr. W. B. Carpenter, edited by Dr. Henry Power. Price 31/6. (Churchills.)

E. *Hygienic.*

The Laws of Health by Prof. Corfield. Price 1/6. (Longmans.)

Health by Prof. Corfield. Price 6/-. (Kegan Paul & Co.)

A Manual of Practical Hygiene by Dr. Parkes, edited by Dr. De Chaumont. Price 18/-. (Churchills.)

Traité d'Hygiène Générale par Dr. Adolphe Motard. 2 vols. Price 13/4. (Baillière.)

Traité d'Hygiène, publique et privée, par Michel Lévy. 2 vols. Price 16/-. (Baillière.)

F. *Food and Dietaries.*

A Brief Guide to the Food Collection of the Bethnal Green Museum. Price 1*d.*

Food by Prof. Church. Price 3/-. (Chapman and Hall.)

Substances used as Food. (S.P.C.K.)

Vegetable Substances used for the Food of Man. (Knight.)

Food by Dr. A. Bernays. Price 1/-. (S.P.C.K.)

Curiosities of Food by P. L. Simmonds.

Our Food by Dr. Lankester. Price 4/-. (Bogue.)

On Food by Dr. H. Letheby. Price 5/-. (Baillière.)

Foods by Dr. E. Smith. Price 5/-. (Kegan Paul & Co.)

Salt, Preserved Provisions and Bread, by J. J. Manley. Price 3/6. (Stanford.)

Butter and Cheese by Morgan Evans. Price 3/6. (Stanford.)

Common Salt. (S.P.C.K.)

Plain Words about Water, by Prof. Church. Price 4*d.* (Chapman and Hall.)

Cocoa by Charles Hewett. Price 1/-. (Spon.)

Coffee and Chicory by P. L. Simmonds. Price 1/-. (Spon.)

A Handy Book on Food and Diet by Dr. C. Cameron. Price 1/-. (Cassell.)

Food and Feeding by Sir Henry Thomson. Price 2/6. (Warne.)

Practical Dietary for Families, &c., by Dr. E. Smith. Price 3/6. (Kegan Paul & Co.)

A Manual of Diet in Health and Disease by Dr. T. K. Chambers. Price 10/6. (Smith, Elder & Co.)

Food and Dietetics by Dr. F. W. Pavy. Price 15/-. (Churchills.)

Précis des Substances Alimentaires, par A. Payen. Price 7/6. (Hachette.)

G. *Adulterations of Food.*

A Key to the Adulterations of our Daily Food by Wm. Dalton. Price 1/-. (Marlborough.)

The Tricks of Trade. Price 1/-. (Routledge.)

On the Composition of Food and how it is Adulterated, by Dr. W. Marcet. Price 6/6. (Churchills.)

The Commercial Handbook of Chemical Analysis by Dr. A. Normandy. Price 12/6. (Lockwood.)

A Food Chart giving Composition, Adulterations, Tests, &c., of common alimentary substances by R. L. Johnston. Price 2/6. (Bogue.)

H. *Cookery.*

A School Cookery Book by C. E. Guthrie Wright. Price 1/-. (Macmillan.)

First Lessons in the Principles of Cooking by Lady Barker. Price 1/-. (Macmillan.)

Food and Home Cookery by Mrs. Buckton. Price 2/-. (Longmans.)

Buckmaster's Cookery. Price 2/6. (Routledge.)

I. *Domestic Economy.*

Manual of Domestic Economy by Dr. Walsh. Price 15/-. (Routledge.)

The Encyclopædia of Domestic Economy by Webster and Parkes. Price 31/6. (Longmans.)

N.B.—For DIAGRAMS, see the Lists prefixed to the following Lectures of the "Science made Easy" Course:—Botany, &c., Lecture VII. Zoology, Lecture VIII. Physiology, Lecture IX.

SYNOPSIS.

Giving the articles referred to in this Book, in the order in which they are displayed on two stands at the beginning of Class V. of the Parkes Museum. Flat specimen Bottles form five rows in each of four shallow dust-proof Show-cases (30 × 24 × 3 ins.), supported in a sloping position on the counters; the Tablets and Diagrams are attached to the Display-board above; and the cumbersome articles are in the Cupboards beneath.

The two-fold object of this classified Index is:

1stly. To establish a reciprocal connection between the Exhibits and the Text, where they are referred to by means of crosses (×).

2ndly. To facilitate the formation of similar Collections on this pattern. Certain London Firms would readily supply estimates. For particulars and advice apply to the Secretary of the Twickenham Economic Museum.

PROXIMATE ORGANIC CONSTITUENTS OF FOOD.

NITROGENOUS.

CASE No. I.

THE ALBUMINOIDS.

Albumin.

Fibrin.

Casein.

THE GELATINOIDS.

Group IV. Organic Acids.

Group V. Coloring Matters.

INORGANIC CONSTITUENTS.

MINERALS IN THE BODY.

PAGE

COMMON SALT.

CASE No. III.

WATER.

CASE No. IV.

Fermentation Products.

Preservation of Food.

Wholesome and Unwholesome Food.

CHAPTER I.

ORGANIC COMPONENTS OF FOOD.

The Term Organic Chemistry.

Animals and Plants differ from Minerals inasmuch as they perform certain functions by means of special appliances called Organs. Thus for example, the mouth and stomach of Animals are Organs by means of which they take in and mainly digest their Food, and the roots and leaves of Plants are Organs by means of which they absorb, and adapt to various purposes, the materials of Nutrition. Hence has arisen the term Organic, which is now given, not only to the various tissues of which Plants and Animals are formed, but also to various products which we derive directly or indirectly from them, and the portion of Chemical Science which treats of these products is called Organic Chemistry. All other portions are united under the title of Inorganic Chemistry.

The number of Organic Products is marvellous, but more marvellous still is the fact that this vast multitude of compounds is mainly made up of four elementary ingredients or constituents, namely:—Carbon, Hydrogen, Oxygen and Nitrogen, which are called

ORGANIC ELEMENTS.* Most of the products derived from the Animal Kingdom contain all four of these Elements, and so do a certain number of those derived from Plants ; but the great majority of the latter products contain only CARBON, HYDROGEN and OXYGEN, and some of the articles resulting from them contain only CARBON and HYDROGEN. Carbon prevails so universally throughout the whole range of Organic Chemistry, that this branch of Science has been named by some, "THE CHEMISTRY OF THE CARBON COMPOUNDS."

Independently however of the above four so-called Organic Elements, other inorganic materials frequently enter into the composition of organic substances. Thus Sulphur and Phosphorus occur in small quantities in some of the most nutritive articles of Food, whilst earthy Salts are found to some extent in most of them ; and Water forms a much more prominent constituent of Plants and Animals than is commonly supposed.

PROXIMATE AND ULTIMATE ANALYSIS OF ORGANIC PRODUCTS.

If we take 100 parts of Wheaten Flour and knead them with water into dough, we can easily wash away from that dough, and obtain separately as a white deposit from the water, about 60 parts of *Starch.* The grayish residue contains about 12 or 13 parts of the sticky substance called *Glutin,* but we can also separate by various means certain smaller quantities of other substances such as Sugar, Fat and Fibre, to say nothing

* Many Chemists place Nitrogen before Oxygen, especially in formulas.

of a notable percentage of Water. Now all the substances which thus together constitute the Wheaten Flour, are said to be its CONSTITUENTS. They are moreover called *Proximate Constituents* as being nearest at hand, and this first process of separation or ANALYSIS, is called PROXIMATE ANALYSIS.

If we take Starch by itself and proceed to analyse it, we obtain proof that it contains Carbon, Hydrogen and Oxygen, and as we know that we cannot go further, these being Elements, or Simple Bodies, we pronounce them to be the *Ultimate Constituents* of Starch, and call this last process of decomposition, ULTIMATE ANALYSIS. In a similar way Glutin may be proved to consist mainly of Carbon, Hydrogen, Oxygen and Nitrogen,* and the same searching investigation may be applied to the other Proximate Constituents of Wheaten Flour, or to those of any other mixed Organic Compound.

Proximate Analyses are in general not only much more easy to perform than Ultimate Analyses, but they also afford a much better criterion of the nutritive properties and wholesomeness of the various Food Articles. An Ultimate Analysis will make no distinction between Vegetable Fibre of the most indigestible description, and wholesome Arrow-root or Sago. It will prove that some of the most palatable essences are *isomeric*, that is to say identical in composition, with the Essential Oil of Turpentine, or Turps, and it will show more Nitrogen, which is generally considered the highest test of nutritiveness, in a piece of gelatinous shin of Beef, than in an equal quantity of the best rump-steak. In fact the same Ultimate Elements which constitute the most nutritious products, might be so built up as to form not only useless articles, but actual poisons.

* A very small percentage of Sulphur is generally present, and according to some chemists traces of Phosphorus.

We can on the contrary, judge at once by a Proximate Analysis, of the nutritive value of almost any Food Article, provided we have made ourselves well acquainted with the properties of the common Proximate Food Constituents, and with the chief modifications they present, and have also gained an insight into the general Rationale of Nutrition.

Chemical and Physiological Classification of Food Constituents.

The various *Organic Constituents* of Food, and the Food Stuffs, or Aliments, in which they respectively predominate, are commonly classed as *Nitrogenous* if they contain Nitrogen, and as *Non-nitrogenous* if they contain none. It is sometimes convenient to call the latter *Carbonaceous*, but it must be understood that this does not by any means imply that Nitrogenous articles are deficient in Carbon, for that element constitutes at the least one half of their weight.

Nitrogenous food constituents mainly divide themselves into ALBUMINOIDS and GELATINOIDS. The Greek ending *oid* which is often used to indicate resemblance, here applying to Albumin and Gelatin respectively.

Non-nitrogenous food constituents similarly form two main groups. The one comprises Fats and Oils, and takes the name of STEAROIDS, *Stearin* being the chief solid constituent of those bodies. The second group which includes Starches and Sugars, is indiscriminately called after the first of these, AMYLOIDS, (from *Amylum*, the Latin for Starch) or after the second SACCHAROIDS. They are also called *Carbohydrates*, for a reason to be explained by-and-by.*

* See page 36.

There are many articles of which the merit lies not in the amount of actual nutrition which they supply, but in the increased value they give to the Food with which they are associated, either by simply rendering it more palatable, or by stimulating the vital powers, facilitating the processes of digestion and assimilation, and diminishing the waste of the tissues. To these ACTING AND FLAVORING PRINCIPLES, or *Food Auxiliaries*, it will be found expedient to devote a special section under the title of ACCESSORY ORGANIC PRINCIPLES.

The *Inorganic Constituents* of Food may be conveniently separated into *solid* and *liquid*. The former division consists chiefly of saline compounds, which when they are left as the residue of combustion in analytical experiments, are often collectively called ASH.—The latter division has but one member,—WATER.

Besides these Chemical forms of classification and nomenclature, others are used of a Physiological character, indicating the purposes which the several Food Stuffs are supposed to subserve in the *economy* of the Human Frame, that is to say in its constitution and functions. Before however considering the varied nature of these purposes, let us take note of a few facts connected with the aggregate amount of nutrition they involve.

The first is the absolute increase of our Body from infancy to the adult age, that is to say, the actual building up of the living fabric, which taken at the usual average, weighs about 11 stone or 154 lbs.* Then there is throughout life a continual outward growth and casting off exemplified by our skin, nails and hair, and an inward production of secretions intended for separation from our system. There is indeed generally inherent

* For a Proximate and an Ultimate Analysis of the Human Body, according to the S. K. Food Directory, see Appendix I.

to vital activity, a cycle of production, functional action, deterioration and elimination. Every muscular action, whether it be outward and voluntary, as in the labour of the arms and legs, or inward and involuntary, as in Respiration or the beatings of the Heart, nay even every exertion of the Brain and Nervous System, involves a certain amount of disintegration, commonly called *wear and tear*, of our muscular or nervous tissue, which must be repaired. It is indeed often made good beyond the extent of the damage, as is shown by the enlargement of our sinews through constant exercise. Now setting aside the adipose or fatty matter,* we may consider that all our soft organs are more or less built up of nitrogenous materials, and it therefore stands to reason that we must take in a certain quantity of nitrogenous aliments, as being alone capable of producing and repairing our substance. Such food-articles are for that reason conveniently called "*plastic*," that is to say, formative or constructive. On the same authority, that of the great German philosopher, Liebig, they are sometimes called FLESH-FORMERS.

In contra-distinction to these Flesh-formers, non-nitrogenous aliments have frequently received the title of HEAT-GIVERS or HEAT-PRODUCERS. You are indeed aware that the Oxygen which the Blood borrows from the Air in passing through the Lungs, consumes during its circulation non-nitrogenous materials, either previously stored up, or directly supplied by daily food, the object being a constant generation of Heat sufficient to maintain the body at a uniform temperature of about 98° F. (37° C.).

It must be borne in mind that the best Heat-givers

* Dr. Carpenter considers Fat as "a constant and important constituent of the muscular, nervous, and other tissues," but many Physiologists consider its deposits, especially in or near the muscular tissue, as merely stores of combustible material.

are fatty matters or Stearoids, which contain free Hydrogen, whereas in the Saccharoids, the Hydrogen is already neutralized as it were by combination with Oxygen, and only the Carbon is available for combustion. Then again in the same manner that the term *Carbonaceous* applied to Non-nitrogenous Foods, does not imply that they have the monopoly of Carbon, so likewise must it be understood that in calling them "Heat-givers," one does not mean to imply that no heat is to be got out of nitrogenous matter. Far from it, for when carbonaceous food fails, the muscles of our flesh will supply material for combustion, rather than that the temperature of the body should fall below the normal warmth. For this purpose their substance splits up, forming on the one hand, hydrocarbonaceous matter which at once serves as fuel, and on the other hand, the peculiar highly nitrogenous compound called *Urea*, which dissolves in the Blood, but being of no service, is strained from it, and expelled from the system by the Kidneys.

On the whole however, fifteen or twenty years ago, peoples' minds had settled down into what then seemed a rather natural division of duties between Nitrogenous and Non-nitrogenous Food. The latter had to do the warming, the former was to minister to the wants of the muscular system, a task of no small magnitude, since it was supposed that these muscles not only generated motion by their contractions, but also originated the force or energy by which those contractions were produced, a certain amount of their substance being consumed in this exercise of dynamic functions. But new ideas arose out of the ingenious and persevering experiments of Dr. Edward Smith, Messrs. Fick and Wislicenus, Dr. Frankland, Dr. Parkes and others. They arrived at the conclusion that the fuel consumed in the production of force, is not derived from the substance of the muscle, but is supplied by the fat stored up for the purpose

amongst its fibres, or rather by the fatty or other carbonaceous matters which the blood carries about with it. In short that the Heat-givers are to a great extent also Force-producers, and that our contractile sinew not generating force, may be likened to an engine set in motion by a power which it does not itself engender.—Such is the predominating opinion at the present time, and it is urged in its favor that the disintegration of our muscular substance evidenced by the discharge of Urea, undergoes during laborious exertion comparatively little increase above the amount to which it is subject during rest. But the matter is not yet established in all its bearings, and there are those who still think that our muscles have a more responsible and onerous duty to perform, than that of merely allowing themselves to be impelled by an extraneous energy. They maintain that it is difficult to account even for the regular daily discharge of about an ounce and a quarter of Urea, which is the average under normal conditions, except by attributing it to an amount of disintegration of our muscular fibre beyond what could arise from the mere friction of a passive machine ; an amount which must therefore be partly connected with the production of energy, if not for voluntary motion, at least for involuntary and permanent labour, like that of the Heart and Lungs. They point also to the facts that "hard work is best performed under a liberal supply of Nitrogen-containing food," that "every structure in the body in which any form of energy is manifested is nitrogenous," and that "if Nitrogen be cut off from the body, the various functions languish," eventuating in what Huxley calls "Nitrogen starvation." Dr. Letheby further says, "The instincts and habits of the human race show beyond all question that a comparatively rich nitrogenous diet is necessary for the proper sustenance of life, especially when work is performed." He also

relates the following instructive fact:—"The Hindoo navvies who were employed in making the tunnel of the Bhore Ghat Railway, found it impossible to sustain their health on a vegetable diet; and being at liberty to eat as they pleased, they took the common food of the English navigators, and were then able to work as vigorously."

Reverting to the question of Classification, which has brought us to the consideration of these conflicting opinions, it may safely be said that whether we regard Nitrogenous Food as directly or indirectly contributing to the production of energy; whether it be for that purpose split into Carbonaceous matter and Urea as it circulates in the Blood, or as it traverses the Liver, or after it has acquired the substantial condition of muscular fibre, or whether in the latter form it merely exercises a catalytic action, looking on and urging Carbonaceous matter to supply by its combustion motive power as well as warmth; it is obviously not on such intricate performances that a Physiological Classification of the infinitely varied multitude of Food substances can, in the present state of our knowledge, be satisfactorily based. At the time when Liebig's system was flourishing, an experiment was made of classifying a Food Collection of first magnitude as "Flesh-formers" and "Heat-givers;" the most incongruous juxtapositions were the inevitable result, and I congratulated myself on having devised for the Food Department of my Economic Museum, the plain common-sense arrangement now adopted in the Parkes Museum, and which, whilst it favours reference by natural associations, affords free scope for chemical aid in the form of Proximate Analyses.* The following are the leading outlines:—

* For an account of the most important modern Classifications of Food, see Appendix II.

CLASSIFICATION OF PROXIMATE CONSTITUENTS OF FOOD.

A.—Organic.

NITROGENOUS.

Albuminoids.

Animal Albumen.
Vegetable Albumen.
Animal Fibrin.
Vegetable Fibrin.
Animal Casein.
Vegetable Casein.

Gelatinoids.

Gelatin.
Ossein.
Chondrin.

NON-NITROGENOUS.

Stearoids.

Stearin.
Palmitin.
Olein.

Stearic Acid.
Palmitic Acid.
Oleic Acid.

Glycerin.

Saccharoids.

Amyloses	Cellulose. Starch. Dextrin. Gum.
Sucroses	Cane Sugar. Beet Sugar. Maple Sugar. Palm Sugar. &c.
Glucoses	Grape Sugar. Starch Sugar. Milk Sugar. Inosite, &c.
Pectin.	

ACCESSORY ORGANIC PRINCIPLES.

(*Nitrogenous and Non-nitrogenous.*)

Alkaloids.

Kreatine.
Kreatinine.
Sarcine.
Theine and Caffeine.
Theobromine.
[Quinine.]
[Morphine.]
[Nicotine.]

Essential Oils.

Hydrocarbons.

Oils of Lemon and Cloves, and other isomers of Essence of Turpentine.
Oil of Peppermint.

Oxidised Essences.

Oil of Aniseed.
" " Cinnamon.
" " Bitter Almonds.

Sulphuretted Essences.

Oils of Mustard and Horse-radish.
Oil of Garlic and its isomers.

Alcohol, &c.

Common Alcohol.
Common Ether.

Acids.

Acetic.
Citric.
Malic.
Tartaric.
Oxalic.
Tannic.
Lactic.
Butyric.
&c.

B.—Inorganic.

Solid.

Common Salt.
Other components of Ash.

Liquid.

Water.

[TABLET No. I.]

ULTIMATE ANALYSES OF LEADING PROXIMATE CONSTITUENTS OF FOOD.

Nitrogenous.

	C	*H*	*N*	*O*	*S*	*P*
Albuminoids.						
Animal Albumin / Vegetable Albumin	53·5	7·0	15·5	22·0	1·6	0·4
Animal Fibrin / Vegetable Fibrin (Glutin)	52·7	6·9	15·4	23·5	1·2	0·3
Animal Casein / Vegetable Casein (Legumin)	53·8	7·1	15·7	22·5	0·9	
Approximate Average	53½	7	15½	22½	1¼	¼
Gelatinoids.						
Gelatin	50·4	6·6	18·4	24·6		
Ossein	50·4	6·5	16·9	26·2		
Chondrin	50·0	6·6	14·4	28·6	0·4	
Approximate Average	50¼	6½	16½	26½		

NITROGENOUS CONSTITUENTS OF FOOD.

The Albuminoids.

Let us now refer to the first of the Tablets specially prepared for bringing into clear relief the Ultimate Analysis of the leading Proximate Constituents of Food (×). We see that whether derived from the Animal or from the Vegetable Kingdom, a close analogy exists between the chief Albuminoids,—Albumin the principle of the White of Egg, Fibrin, that of muscular Fibre, and Casein that of Cheese,—as regards their chemical composition. This resemblance extends to their properties; so much so that by some chemists they have been considered as mere modifications of a single body, supposed to have slight acid qualities, and which on account of its mutability has been called Protein.

General Properties of the Albuminoids.

They are not crystallizable.

When they are in the liquid state, causes special to each kind induce them to become solid, or to *coagulate.*

When in the solid state, they can easily be dissolved in an alkaline solution with the aid of heat; or in pure water at a temperature a little above 300°,* a fact which we shall find to be of considerable importance.†

* All Temperatures, where not otherwise indicated, are according to Fahrenheit's scale; the Centigrade Scale having unfortunately not yet become sufficiently popularised in this country.

† Miller indicates 302° as the Temperature at which Albumin and Fibrin become soluble when heated with Water in a sealed tube.

They are precipitated by solutions of Copper, Lead, and Mercury.

A solution containing only a hundred-thousandth part of an Albuminoid is perceptibly reddened by Nitrate of Mercury.

The Albuminoids may fairly be considered as the most nutritive of Foods, subject however to a very great difference in their degree of digestibility, according as they are in a liquid or solid, comminuted or compact, soft or indurated condition. All Albuminoids are brought by digestion to the peculiar form called *Albuminose* or *Albuminous Peptone*, which is that in which they are absorbed by the Lacteals.* From this Peptone, Albumin, Fibrin, and Casein can be reproduced. Gelatin can also be produced from it, as is proved by the fact that Gelatin is found in the bodies of animals that live on vegetable diet, in which Gelatin does not exist itself, nor anything but albuminoid matter from which it could be produced.

Albuminoid or Proteid matter is not confined to animals. VEGETABLE ALBUMINOIDS are scarcely distinguishable in their composition and properties from the corresponding ones supplied by the Animal Kingdom.

ALBUMIN.

Let us turn to the actual specimens contained in the first of our Show-trays, in order to obtain a more substantial notion of the forms and properties of the chief Albuminoids.

The whitish curds floating in spirit in the small bottle

* According to some authors there are several varieties of Peptone, some susceptible of absorption by the vessels of the Stomach itself.

which stands first in the upper row (×), may be considered in some measure as representing the whole albuminoid group, for it is nothing less than Mulder's Protein, that is to say the original type to which Mulder thought he could reduce the several varieties of Albuminous matter.

The next three bottles display samples of Albumin in that well-known form in which nature presents it to us so abundantly in an almost pure state, viz. as White of Egg, which in contra-distinction to the chemically pure constituent Album*in* we will call Album*en*. It generally makes itself very disagreeable when one attempts to preserve it in the raw liquid state, but by filling a glass-stoppered bottle with it, so as to exclude as much as possible all air, it may, as shown by the specimen (×), be made to retain its original appearance, though not its goodness, for some time. In the next bottle (×) it presents a heap of small yellowish semi-transparent scales, obtained by carefully drying it at a heat not exceeding 122°. It is important to remember that at 140° F. (60°C.) Albumin begins to pass into the solid opaque condition exhibited in the next bottle (×), which contains, preserved in spirit, the "white" of a hard-boiled egg. It is an interesting but merely chemical experiment, to re-dissolve this tough and apparently insoluble mass, by simply raising under pressure the temperature of the water containing it to about 302° F. (150° C.), but it is much more convenient to prepare a solution like that in the next bottle (×), by boiling the hard white of egg in water containing a small quantity of Potassa, or in any other weak alkaline solution. The fact is that Albumin possesses slightly acid properties, forming definite compounds with many of the metallic oxides. Thus the liquid in our bottle may be considered as a solution of Albuminate of Potassa. From it, Acetic Acid would throw

down the Albumin in white flakes like those of Mulder's Protein. The next specimen (×) shows that the same Acetic Acid produces a coagulum in the raw white of egg. One naturally jumps to the conclusion that Albumin in this natural condition is combined with an Alkali, and one is rather surprised to find that the quantity of Soda contained in white of egg is scarcely more than $1\frac{1}{2}$ per cent.*

Albumin can also be coagulated by Alcohol and by Kreasote, and by solutions of Alum, and of many metallic salts, as those of Copper, Lead, and Mercury. It is therefore useful to administer raw White of Egg in cases of poisoning by these salts, in combining with which the solidified Albumen forms a protective coating to the walls of the stomach.

In our own body and in that of animals in general, Albumen is an abundant constituent. It occurs in large proportion in many of the organs, as in the brain, kidneys, &c., and forms about 7 per cent. of the entire mass of the Blood, from the Serum of which it can be easily separated through coagulation by heat. Much more useful however is the soluble kind obtained by the evaporation process. The specimen thus procured (×), probably from the serum of bullock's blood, and which bears the name of Ser-albumen to distinguish it from the Ov-albumen or Egg Albumen, is manufactured commercially, not as food, but for performing a rather important function in the dyer's vat. Certain colours which readily adhere to woollen yarns, refuse to fix themselves on to cotton; but when these are coated with animal matter by immersion in a solution of Ser-

* Singularly enough, Albumin performs towards certain acids the part of a Base. This aptitude to serve either purpose is possessed more or less by the whole Albuminoid group, but Albumin itself manifests it in a remarkable degree.

albumen, or to use a technical phrase, when they are *animalized*, the difficulty is overcome.

The kind of Albumen called *Globulin* occurs very largely in the Blood Corpuscules. Mixed in the red ones with about $\frac{1}{20}$ of colouring matter, Hæmatin, it assumes the name of Hæmoglobulin.

Vitellin, derived from the Yolk of the Egg, and many other varieties, are all referable to the type Albumen.

VEGETABLE ALBUMIN (×). This name is given to a substance almost identical with Animal Albumin, which occurs in the juices of many plants, as for instance Carrots, Turnips, &c. It also occurs mixed with the starchy matter of seeds, and Wheat Flour, from which it is generally extracted, contains about 1·8 per cent. This substance appears to be particularly prone to spontaneous decomposition, whereby it becomes, under the name of *Diastase*, the instigator of those changes in the condition of the grain which are known by the name of the Saccharine Fermentation, and which in the case of Barley, effect its conversion into Malt. Miller says that Diastase is "probably merely Albumin or Glutin in a particular stage of decomposition."

FIBRIN.

It is in the liquid or uncoagulated form, that Albumin seems to accomplish nearly all its useful functions in the human economy. Fibrin has solid as well as liquid duties to perform. In the *solid* state it constitutes the bundles of minute *fibres* from which it takes its name, and of which all the muscles of our body are constructed. These fibres, well cleansed, may be dissolved in Water containing Hydrochloric Acid, and precipitated by an Alkali in a purified form, which takes the name of

Syntonin.* We have in our show-tray a small quantity in spirit (×). The *liquid* state is that in which Fibrin circulates throughout the system, dissolved in the Serum of the Blood, not by any chemical process, but by the action of mysterious agencies which transcend the limits of philosophical research, and are commonly designated by the term *Vitality.* It is well known that Blood withdrawn from vital influence, either by death, or separation from the body, coagulates, forming what is called the "Clot" of the Blood. From this clot, nearly pure Fibrin, to the extent of about one quarter per cent. of the Blood employed, can be obtained by washing till the red color disappears. The Fibrin may also be procured by agitating fresh Blood with a bundle of twigs. On these it collects in the form of elastic strings, which should be well washed. They are insoluble in water, tasteless, and colorless, as shown by the sample in spirit (×). When dried, Fibrin assumes the light fawn color of the specimen in the next bottle (×).

The degree of solubility in dilute Hydrochloric Acid affords a marked distinction between this Blood Fibrin, and pure Muscle Fibrin, or Syntonin, the proportion of acid in water required for the latter being only one part in a thousand, whereas even one part in ten effects only an imperfect solution of Blood Fibrin. A very convenient test is thus afforded for ascertaining the relative proportions of real Syntonin in various kinds of meat, and especially in full grown, as compared with young meat. Thus with lean Beef, the residue remaining after the action of the dilute Acid at a temperature, say of 100°, will consist of little else than vascular tissue and fat, whereas in the case of Veal, a considerable portion of the Fibrin will remain undissolved, manifesting an evident approximation to the character of Blood

* Syntonin may also be obtained chemically from Albumin.

Fibrin. The case is the same with Lamb as compared with Mutton, and these differences afford a very useful criterion as to differences of digestibility.* Besides the differences of digestibility thus produced, others arise from the processes to which Fibrin is often subjected with a view to its preservation. Thus for instance it is well known that digestible Beef may become very hard of digestion as salt-junk, and yet singularly enough, a solution of Common Salt possesses the property of preventing the coagulation of the fluid Fibrin in fresh Blood.

It will be remembered that Fibrin, in order to be accepted by the Lacteals, must be digested into the form of a peculiar Peptone. It is something similar to this Peptone that is provided by the process of dissolving meat in Pepsine, the acting principle of the Gastric Juice, obtained from the stomach of the Pig. Nothing can be more appropriate in cases where it is necessary to spare as much as possible the action of the digestive powers. The same result, or nearly so, is obtainable by using a solution of Fibrin in Hydrochloric Acid so dilute as to be easily rendered palatable. There might be scope for useful experiment in the employment of Fibrin dissolved in Water with the aid of a Papin's Digester at a temperature slightly over 300° (×).

* Fibrin treated with Acetic Acid is found to consist of a granular part which becomes dissolved, and of a fibrous part which remains. They are almost identical in composition.

The percentages of Oxygen respectively contained in Ov-Albumin, Blood Fibrin, and Syntonin are 22, 23½, and 25. Hence some chemists regard Blood Fibrin as a stage of transition between Albumin and Animal Tissue.

GLUTIN OR VEGETABLE FIBRIN resembles Animal Fibrin in consistency, as well as in composition, at least when pure, for in its ordinary condition which bears the name of *Gluten*, it contains, among other things, a sticky substance soluble in hot Alcohol and Ether, called *Gliadin*, which renders it adhesive. We have a specimen of the crude Gluten well preserved in spirit (×), and which is of a pale color, whilst the next bottle (×) shows the hard brown pieces into which it is changed by drying. Besides its pre-eminence as a nutritive constituent of Wheaten Flour, Gluten imparts to the dough, through the tenacity of its Gliadin, the susceptibility *to rise* when inflated by Carbonic Acid Gas, produced by fermentation or otherwise, thus rendering the Bread spongy and light.

CASEIN.

This third form of Albuminoid- or Proteid- matter, of which we have two specimens (×), one in spirit, the other dried, occurs like the preceding ones, in a liquid and a solid condition, but the transition from the former to the latter, instead of being caused by the application of Heat, or the subtraction of Vitality, is generally produced, either, by the action of Acids, or by the extraordinary influence of the mysterious agent contained in RENNET, or RUNNET. This name is given to the inner membrane of the fourth stomach of the Calf, which is commonly kept salted and dried for the purpose. An infusion of it being added to cow's Milk previously warmed, the Casein, amounting to about 4 per cent., is coagulated in the form of curds, which suitably pressed, form Cheese. The latter when poor, that is to say, made from skimmed Milk, consists almost entirely of Casein,

though some trouble is required to produce that constituent in the pure condition of our specimens. Most Cheeses are comparatively insipid at first, and only acquire their proper flavor by a kind of gradual decomposition, which from the fatty particles appears to extend to the Casein itself, but which varies in character according to the nature of the Cheese, and the circumstances in which it is kept. Thus some kinds slowly attain to the dry pungency prized as stimulant and stomachic by the Swiss mountaineers, whilst other kinds subjected to a more rapid change, present, as in some parts of France, a partial transition to a semi-fluid adipose matter, with rich flavor but offensive odour.—A still quicker transition in the consistency of Casein, is that occasioned by its oxidation on the surface of boiled Milk, whereby a thin skin or pellicle is produced.

The fact that Casein is the only flesh-forming constituent of Milk, speaks at once for its nutritiveness, and for its digestibility when in a fluid state, as in fresh Milk. It suits also when mixed with fatty particles as in Cheese of good quality, whereas on the contrary, it is indigestible in the compact form presented by many of the poorer Cheeses, and conspicuously in that known as "Suffolk bank."

In common with the other Albuminoids, and indeed in a pre-eminent degree, Casein combines with Lime and its salts, especially with the Phosphate, which it may be considered as instrumental in introducing into the system.

LEGUMIN, of which you see a small specimen in the form of a yellowish sediment preserved in dilute Acetic Acid (×), has for being considered as *Vegetable Casein*, no less an authority than Liebig, and no less a practical plea than coagulability by Rennet. It is said that the Chinese give proof of this by making Cheese out of Peas

and Beans and other kinds of Pulse. Dried Peas contain as much as 22·4 per cent. of Legumin, and Lentils as much as 24 per cent., so that they have hitherto been supposed to be among the most nutritive products of the Vegetable Kingdom; with no other drawback than a tendency, under certain circumstances, to occasion flatulency, a defect which is in some measure common to Animal Casein itself. Unfortunately for the Vegetarians, a serious doubt has been cast on the dietetic value of Legumin by experiments performed in Germany, which tend to show that in common with the other Vegetable Albuminoids, it is less digestible than the corresponding Proximate Constituent derived from the Animal Kingdom, though it is materially improved by long boiling. The subject is of such importance that I hope that it may have emerged from its present condition of doubt and controversy by the time we arrive at the Pulses in the review of the Food Resources supplied by the Vegetable Kingdom.

THE GELATINOIDS.

This group takes its name from the substance so well known in all well-appointed kitchens under the name of GELATIN (×).* As shown by the analyses of the three kinds, Gelatin, Ossein and Chondrin, named on our Tablet No. 1, the chemical difference from the Albuminoids is not considerable. In a physiological point of view the change is far greater. We shall presently find that the alimentary value even of Gelatin itself, has more than once been called in question. There are indeed certain spurious members of the group which cannot be reckoned as Food at all, and which we have accordingly not included in our Tablets. The chief of them is called KERATIN or *horny* principle. It imparts toughness to Nails and Hoofs, and as the chief constituent of Hair and Feathers, is so indigestible as to be absolutely injurious. Not long ago a lady died through having contracted the habit of swallowing portions of her own hair.†

GELATIN proper abounds in the skin, mucous membranes, connective tissue, tendons and ligaments. The variety called OSSEIN, or Gelatin of the Bones, repre-

* The variety adverted to is the French or Sheet Gelatin, which stands second in the order of display of this series. An instance here presents itself of references occurring in a different order from that in which it is found expedient to arrange the articles displayed. One of the objects of the SYNOPSIS OF ILLUSTRATIONS (p. xxix.) is to prevent the confusion which might arise from such differences.

† It is to be regretted that a satisfactory and definite understanding in reference to the classification of the Gelatinoids has not yet been arrived at by the various chemical and physiological authors. In the meantime it may be best to reserve the term Keratin for those kinds which cannot be made to produce a gelatinized substance.

sented by a small bone deprived of its mineral matter by soaking in dilute Hydrochloric Acid (×) is, as shown by our Tablet, but a mere trifle removed in chemical composition from true Gelatin, and shares nearly all its properties. CHONDRIN obtained by boiling Cartilage or Gristle (×) is more distinct, but still possesses to a certain extent the extraordinary property to which Gelatin owes its culinary value, namely *Gelatinization.* Take Gelatin in its raw state and treat it with cold water, it will only swell up; but if the water be maintained for a certain time at a temperature varying from the boiling heat to considerably below it, according to the more or less fibrous nature of the material employed, it will become dissolved, and on cooling it will *Gelatinize,* that is to say, it will solidify into a jelly, incorporating an enormous quantity of the liquid, amounting in some cases to one hundred times its own weight. If however the process of heating and cooling be repeated, or the boiling too much prolonged, this power of gelatinizing gradually decreases. Carpenters are well aware that their Glue, which is but a coarse quality of Gelatin, refuses to do its duty after having been warmed more than a reasonable number of times.

Gelatinous solutions exposed to the air have, especially in warm weather, a tendency to Acid Fermentation, which should not be disregarded, for it sometimes disagrees with the stomach before it offends the palate. The same is the case with weak jellies; but when Gelatin is sufficiently concentrated, it becomes hard on cooling, and is durable if kept dry. Still however its condition differs essentially from that of its original raw material. A slip of thin French Gelatin immersed in warm water for a short time, does not merely swell up like a piece of raw skin, but its surface is partially dissolved. Thus the combined warmth and moisture of the mouth, have on

such slips an immediate effect which may be turned to good account for attaching sheets of paper firmly by a very narrow surface. Gelatin wafers were deservedly much used before adhesive envelopes came into fashion, and mouth-glue, which is but prepared Gelatin, is still in use.

Gelatin is less generally precipitated than Albumin from its solutions by Metallic Salts, and by Acids, but is remarkably so by Tannic Acid. This latter affords a peculiarly delicate test, as it will detect one part of Gelatin in as much as 5000 parts of Water. The product thrown down as a buff-colored precipitate, of which we have a specimen preserved in spirit (×), is extremely interesting through its identity with that all important article,—Leather. The fact that the Tannic Acid of Bark and other similar substances converts into Leather the Gelatin of Skins, had led to the supposition that there could be no real difference between the raw insoluble material which skins contain, and the soluble Gelatin obtained from them by boiling; but a closer investigation has shown that it is only through a change into true Gelatin effected by incipient decomposition, that the crude material becomes capable of being tanned.

The circumstance that Gelatin is soluble in Acetic Acid, explains the manufacture of the so-called *Finings* by treating it with sour Beer or Wine. It is on the contrary not soluble in Alcohol, and this may somewhat account for what takes place when these Finings are added to turbid wines or malt liquors. The Gelatin is precipitated as a fleecy cloud, which, in gradually settling, carries down the suspended impurities, leaving the liquid beautifully *clarified.*

Chondrin is not soluble in Acetic Acid, which on the contrary precipitates it from its aqueous solutions, and this is the chief test for distinguishing it from Gelatin and Ossein.

From the chemical properties of Gelatin, let us pass to its commercial supply, as illustrated by a few specimens in our Table Case :—The first bottle shows it in the purest natural form, Isinglass (×), which consists of the dried shreds of the inner membrane of the Sound or Air-bladder of the Sturgeon, the Cod, and a few other fishes. No other kind has been found to equal this in the quantity of water which it will gelatinize. But its price, which is about 1*s.* per ounce, far outweighs its superiority in this respect over the kind now commonly used, called French Gelatin from its having been first perfected in France, or Sheet Gelatin from its being sold in thin sheets beautifully clear (×). It may also be had in shreds which from their color are called Amber Gelatin (×). The prices of these substitutes range from 2*s.* to 4*s.* per pound according to the quality of the article and of the shop. Next you see a bottle containing a superior product (×) cut into filaments, that it may be more readily dissolved, look more fashionable, and realise a genteel price.*

The word Gelatin must here be taken in a rather comprehensive sense. Much of the manufactured product really is Ossein obtained, not like our specimen already referred to by dissolving away the earthy portion of Bone with Hydrochloric Acid, but by submitting crushed fragments of bones to a jet of steam at about 302° F. (150° C.) whereby the Ossein is dissolved away, leaving behind the Phosphate and Carbonate of Lime. This is a rapid completion of the slow and imperfect process of the Housewife, who boils bones to make stock. In both operations the Chondrin of the Cartilages is generally included without any visible detriment.

* 6*d.* per ounce-packet is the nominal price, but cheap establishments sell it as low as 3½*d.*

But of what importance are all these considerations compared with the great question,—is or is not Gelatin really nutritious? There is something strangely paradoxical in the idea that a substance which covers the whole of our body, constitutes some of its strongest material, and permeates in the form of Connective Tissue the very sinews of our flesh, and which in short, according to the usual rule, "what we are made up of we must take in," would be one of the most useful articles of Food, is no Food at all. And yet such is the verdict pronounced by some of the most competent judges. They appear mainly to base it on the Report published in 1841 by a French Commission specially appointed to enquire into the nutritive value of Bones. Its researches proved that though the *raw* gelatinous material of Bone can sustain life in dogs, the Gelatin derived from it by boiling, cannot. This fact was gravely confirmed by a Dutch Commission in 1844, but it loses much of its importance when we consider that any one of the Albuminoids, taken by itself, would almost equally prove a failure.*

Towards the year 1859 Dr. Edward Smith threw a new light on the subject, by experiments conducted with his usual spirit of patient investigation, proving by the increased exhalation of Carbonic Acid after the introduction of Gelatin into the system, that it mainly undergoes the process of oxidation, whether it be for the development of energy, or the production of heat. This is confirmed by a corresponding elimination of Urea, showing that Gelatin in common with other nitrogenous substances, when required to supply fuel, splits up into that highly nitrogenised product, and a combustible hydro-carbonaceous compound.

* According to the experiments of Tiedeman and Gmelin, Geese were actually starved on an abundant supply of White of Egg.

These data however, whilst somewhat limiting the range of discussion, appear rather to have given it fresh activity than otherwise. Certain physiologists, starting apparently from the fact that animals living on vegetable food must derive their Gelatin from the Proteid Matter of Plants, have arrived at a conclusion that in the human economy the same source must be looked to for supplying the gelatinous portions of our frame. Yet Bischoff and Voit are of opinion that Gelatin presents to some extent a substitute for other plastic matter, and Dr. Letheby in his important Lectures on Food at the Society of Arts says, "possibly it may serve in the direct nutrition of gelatinous tissue."

Some authors cut short the argument by affirming that Gelatin is never found in the Blood, but others on the contrary accord to it the special privilege of dispensing with the ordinary forms of assimilation, and of being in virtue of its perfect solubility taken up at once by the simple act of physical absorption, or *endosmose;* forgetting that according to the principles of dialysis laid down by Professor Graham, Gelatin is a *Colloid* and therefore little susceptible of *osmosis.* Perhaps an equitable compromise may be effected by admitting, (and we have good authority for it) that Gelatin is altered by digestion from its previous sluggish consistency to the pre-eminently diffusible condition of a Peptone.

Be this as it may, we may safely assume with Dr. Corfield that Gelatin—"can take the place of part of the nitrogenous substances which are being oxidised in the Blood." That Hygienist rightly dwells on the importance which this gives it as a food for invalids, obviating the waste of tissue in respect of which their inability to digest ordinary meals, leaves them no other mode of prevention. I am inclined to go further, and not to confine

the benefit of gelatinous nourishment to the sick or the dyspeptic. I have some faith in Soups, and am inclined to share the opinion lately expressed by the above eminent Hygienist, that dietetic notions which have grown out of the experience of centuries, may have some truth at the bottom of them, though Scientists have not yet discovered exactly in what direction it lies.*

The subject of Dietaries will afford a more fitting opportunity for discussing the practice of beginning meals with Soups, and glancing at the epicurean amusement of eating jellies that melt away in the mouth; but I may at once remark in respect of using jellies as food, that the enormous difference between the quantity apparently taken in, and the real amount of aliment, must not be overlooked in computing the nutritive results.

* The significant fact that the Gelatin of raw bones is capable of nourishing dogs that would starve on the Gelatin boiled away from them, shows that the nutritiveness of this paradoxical substance is a matter of form and circumstance. Considering that even in Inorganic Chemistry there are instances of changes promoted by the simple presence of bodies that are mere lookers-on, neither gaining nor losing by the transaction, and that in Organic Chemistry still more striking instances of the power of inducement and example are afforded by the Ferments, are we not justified in supposing that when Gelatin finds itself in our stomachs in suitable circumstances, with peculiarly congenial companions, it does as they do, and goes the way it is wanted?

NON-NITROGENOUS CONSTITUENTS OF FOOD.

THE STEAROIDS OR FATS.

Passing now from the *nitrogenous* to the *non-nitrogenous* or *carbonaceous* Constituents of Food, namely the STEAROIDS and the SACCHAROIDS, we assign the foremost place among these to the Stearoids; for Fat is largely disseminated among our Tissues, which is not the case with the Saccharoids, and it is indeed by many considered as a necessary part of our flesh, so that fatty aliments may to a certain extent be considered as *plastic* or *formative* Food. A more important reason however is, that the special purpose of non-nitrogenous Food, is to support Combustion for the production either of Force or of Heat, and that Stearoids, as has already been stated, are better fuel than the Saccharoids. In the latter, the Hydrogen and Oxygen are as nearly as possible in the proportion required for forming water, namely 8 parts in weight of Oxygen for every one of Hydrogen. Hence the title given to them of Carbo-hydrates, or Hydrates of Carbon, sufficiently denoting that only the Carbon is available for combustion. On the contrary, the Stearoids have in addition to the Carbon a large available amount of free Hydrogen, as may be seen by our Tablet No. 2 (×). It is to this that is attributed the efficacy of a fatty diet in preserving the Esquimaux and other inhabitants of arctic regions against the excessive rigor of their climate.

The Stearoids have several other peculiarities worth remembering:—It is rather interesting to know that fatty bodies obtained from warm-blooded animals are

generally solid at ordinary temperatures, whilst those from cold-blooded animals are liquid. But more important is the fact that their composition is the same whether they belong to the Animal or Vegetable Kingdom. In order to impress this on the memory, our show-tray displays side by side, Animal Fat represented by Tallow, (×) and Vegetable Fat by the substance commonly known as Palm Oil, (×) obtained from the fruit of one of the Palms of Western Africa, and which though liquid in those hot regions, is a solid fat in our cooler climate. Then again by the side of Sperm Oil (×), which stands for the Animal Oils, is Vegetable Oil of Olives.(×) Another peculiarity is that all ordinary Fats and Oils are mixtures in varying proportions of certain distinct though closely allied bodies. Suppose for instance we take a quantity of Tallow, and submit it slightly warmed to a powerful pressure; we shall find that we can squeeze from it a certain quantity of clear fluid labelled *Olein,* (×) a name derived from its being a constant constituent of Oils. Similarly the indurated residue is called *Stearin* (×) from the Greek name for suet. It is not however so exclusively the solid principle of Fats as Olein is the fluid principle of Oils, for another stiffening agent has been discovered in Palm Oil, which has received the appropriate name of *Palmitin* (×), though it is found in many other kinds of Fat, including that of the human body. Generally speaking, Stearin predominates in Animal Fats, and Palmitin in Vegetable ones.

If instead of warming and squeezing a Fat, you submit one of the Oils, whether animal or vegetable, to a temperature sufficiently low to throw down a congealed deposit, you will find on carefully separating the latter by filtration, that you have again on the one hand Stearin replaced perhaps more or less by Palmitin, and on the other hand, the Olein in which they were dissolved.

[TABLET No. 2.]

ULTIMATE ANALYSES OF LEADING PROXIMATE CONSTITUENTS OF FOOD (continued).

Non-nitrogenous.

Stearoids or *Fats.*

		C	H	O
Stearin	Glyceryl Stearate $(C_3H_5)(C_{18}H_{35}O_2)_3$	76·85	12·36	10·79
Palmitin	Glyceryl Palmitate $(C_3H_5)(C_{16}H_{31}O_2)_3$	75·93	12·16	11·91
Olein	Glyceryl Oleate $(C_3H_5)(C_{18}H_{33}O_2)_3$	77·38	11·76	10·86
	Approximate Average	76¾	12·0	11¼
Stearic Acid	$(C_{18}H_{36}O_2)$	76·05	12·68	11·27
Palmitic "	$(C_{16}H_{32}O_2)$	75·00	12·50	12·50
Oleic "	$(C_{18}H_{34}O_2)$	76·59	12·06	11·35
Glycerin	$(C_3H_8O_3)$	39·13	8·70	52·17
Glyceryl	(C_3H_5)	87·8	12·2	

Thus we have made out the three Stearoids of which the specimens are in the Tray, and the analyses on our Tablet No. 2. There are several others in the Fats and Oils supplied by various plants or animals, but they may either be considered as varieties of the foregoing, or if distinct, they are not to be compared with them in importance.*

As for the *Margarin* which used to be constantly mentioned in former chemical works, it is now generally considered to be a mixture of Palmitin and Stearin.

For those who would confine their acquaintance with the Stearoids to the condition in which they present themselves in our daily Food, the foregoing may suffice; but it is a matter of considerable interest to look further into their chemical constitution, which is not without connection with the functions of some of our internal organs, and which has an important bearing on those of our outer skin, through the cleanliness resulting from the use of SOAP. That article is produced by the association of an Alkali with certain Fatty Acids, which Stearoids contain, each having its own.

Thus our show-tray displays by the side of Stearin, its peculiar Stearic Acid (×), by that of Palmitin, Palmitic Acid (×) and next to Olein, Oleic Acid (×). In this country substantial Fats in which Stearin and consequently Stearic Acid prevail, form the chief supply of the Soap-boiler's vat. In places where Olive Oil abounds, as for instance at Marseilles, Olein plays a leading part. The alkali used is mostly Soda, though Potash is employed for Soft Soaps. In all cases the alkali in uniting with the acid, sets free a peculiar body with which the acid was combined. This body called *Glyceryl* has never yet been seen; and for this reason, that at the moment

* For an account of them see, for instance, Miller's "Organic Chemistry."

of parting company with the acid, it combines with definite quantities of Oxygen and Hydrogen, and is thereby converted into the remarkably smooth, bland, and at the same time sweetish fluid which bears the well-known name of GLYCERIN (×). This latter product is also obtained in candle factories, where Stearin and Palmitin are subjected to the action of super-heated steam. It is by this means obtained of excellent quality, whilst the respective acids are collected in that beautiful translucid whiteness, which coupled with their strong illuminating power, has enabled them almost entirely to supersede the former expensive wax candles.

Glycerin is much used medicinally, and though it is not itself an article of Food, it is very useful in preserving for museum display, articles of Food that are otherwise difficult to keep.*

It is chiefly in the Intestinal Canal, and notably through the instrumentality of the Bile, that stearoid matter becomes either saponified, or sufficiently comminuted to allow of its being absorbed by the Lacteals. Different kinds of fat and oil differ very considerably as to their aptitude for such elaboration: hence the peculiar care with which they should be selected in cases where, like Cod-liver Oil or Cream, they have to be administered medicinally. Nor must these differences be neglected in a dietetic point of view, any more than the individual capabilities of digesting Fat, which vary in a notable degree, and are mostly indicated by inclination or aversion.

The fat of meat when exposed to a high temperature as in roasting, grilling, and the like, is apt to decompose, giving rise to certain offensive vapors, and to an acrid

* The Specific Gravities of the articles above described are as follows. Glycerin 1·27: Stearic Acid about 1·00: Palmitic Acid under 1: Oleic Acid ·898.

volatile substance called *Acrolein* (×), which affects the eyes of those engaged at the frying pan, and the stomach of those who partake of its contents, causing in particular the sensation known as heart-burn.*

Another consideration to be borne in mind is the greater or lesser tendency of various Fats and Oils to become what is called *rancid*, acquiring a nauseous smell, a repulsive taste, and a noxious condition more or less affecting the stomach. This occurs through the formation of certain peculiar acids † under the influence of a fermenting agent, which is mostly engendered by the decomposition of nitrogenous matter. Hence the superior *keeping* quality of Fats that have been freed by proper straining from the nitrogenous films which they contained. Among the vegetable Fats several, as for instance Cacao Butter, and that of the Ground Nut, (Arachis hypogœa) are remarkable for their durability.

THE SACCHAROIDS.

The resemblance to *saccharine* matter, or Sugar, implied by the word SACCHAROIDS, is not one of external or visible properties, for they vary considerably in appearance, and present every stage from perfect insolubility, to dissolving in less than their own bulk of water. It is a resemblance in chemical constitution which those external divergencies render truly remarkable, as may be seen by Tablet No. 3 (×).‡ In all of them, the Hydrogen and Oxygen are in the proper pro-

* Acrolein may be considered as derived from Glycerin by the loss of two molecules of water. Its formula is C_3H_4O.

† Butyric, Capric, &c.

‡ See the account of the Saccharoids in Lecture VI. of "Science made Easy."

portion for forming water, but the name of CARBO-HYDRATES which, as already explained, has been given them in consequence, must not induce you to suppose that these elements are actually united in the form of Water, or are more closely combined with each other than they are with the Carbon. All three are in a state of perfect union, intimate yet easily broken, for we shall see in dealing with the subject of Fermentation, that it may be disturbed by agencies extremely feeble in appearance.

The Saccharoids, chemically considered, are generally separated into AMYLOSES, SUCROSES and GLUCOSES.*

For our present hygienic purpose, it will be more convenient to split up the Amyloses, or Starch Group, into four sub-groups, which though identical in composition, differ considerably in properties. Thus we shall have the following six divisions :—

CELLULOSE, the chief material of Vegetable Fibre.

STARCH, or rather THE STARCHES, for there is a whole family of them.

* Their respective formulas may, for the convenience of comparison, be given as follows :—

Amyloses $C_{12}H_{20}O_{10}$, usually written $C_6H_{10}O_5$.
Sucroses $C_{12}H_{22}O_{11}$.
Glucoses $C_{12}H_{24}O_{12}$, usually written $C_6H_{12}O_6$.

Thus it is seen that 12 atoms of Carbon successively combine with 10, 11, and 12 atoms of Water.

Some diversity of opinion prevails as to the places to be respectively assigned to Gum and Lactose, on account of the uncertainty as to the amount of Water which should be considered as an integral part of their constitution. Thus Gum in its ordinary condition may be considered as a Sucrose, whereas submitted to a temperature of 257° it loses an atom of Water, and becomes an Amylose. Similarly, Lactose by being dried at a temperature of 284° may be reduced from a Glucose to a Sucrose.

[TABLET No. 3.]

ULTIMATE ANALYSES OF LEADING PROXIMATE CONSTITUENTS OF FOOD (continued).

Non-Nitrogenous (continued).

Saccharoids.		*C*	*H*	*O*
Amyloses $C_{12}H_{20}O_{10}$	1. Cellulose 2. Starch 3. Dextrin 4. Gum	44·444	6·173	49·382
Sucroses $C_{12}H_{22}O_{11}$	1. Cane Sugar 2. Beet ,, 3. Maple ,, 4. Palm ,, &c.	42·12	6·44	51·44
Glucoses $C_{12}H_{24}O_{12}$	1. Grape Sugar 2. Starch ,, 3. Milk ,, 4. Inosite &c.	40·0	6·66	53·34
Pectin	$C_2H_3O_2$	40·68	5·08	54·24

DEXTRIN, which is Starch converted into a gum-like substance.

THE GUMS; separable into those freely soluble in Water, and those which only form mucilages.

THE SUGARS PROPER, or SUCROSES, in which it is optional to include Milk Sugar.

THE GRAPE SUGARS or GLUCOSES.

CELLULOSE.

Many persons may be inclined to pronounce at first thought, that CELLULOSE has no legitimate title to be associated with regular aliments. It is indeed insoluble and indigestible in the indurated condition in which it forms the woody substance of trees, the tenacious fibres of the flax shown in the first bottle of our Saccharoid Group, (×) or the tough scales of coarse bran contained in the second bottle (×); but it must be remembered that all the organs of plants owe their origin to minute Cells, which as long as they are endowed with power to grow and multiply, are so many sacs or vesicles of most delicate material, containing nitrogenous protoplasm, in which is imbedded the machinery of life.* In this condition the cell walls are as digestible as their contents are nutritious. Nor do they all lengthen into tough fibres, or build up resistant ducts. Many, accumulated as Cellular Tissue or Parenchyma, preserve their delicate texture and their vitality in order to perform the manifold functions of leaves, and may consequently be eaten with advantage, as Spinach (×), Cabbage, and the like, or the whole structure of a plant may remain fit to be devoured raw, as in the case of Lettuce; or again cells engendered in the process of

* See Lecture VII. of "Science made Easy."

fructification, may constitute the wholesome tissue of an Apple (×), or the more refined flesh of a Strawberry. In all these cases we must not overlook the very notable amount of soft and digestible cell-stuff, or *Cellulose*, merely because it conveys juices more palatable than itself, or encompasses materials more nutritious.

Starch.

Let us now proceed to our second sub-group the Starches, represented by Wheat Starch (×), and of which an illustration might equally have been borrowed from other sources. We find on examination, that a peculiar substance, known among Botanists as *Granulose*, is contained in cells or vesicles of Cellulose, which have served to collect it, and the size, shape, and special marking of which vary according to the kind of Starch examined. Cold water does not dissolve these cells, but causes them to swell up to as much as twenty or thirty times their original size, and if the temperature be raised above 140° the cell-walls burst, becoming mixed with the softened contents, and contributing to give to the *mucilage* or slime thus formed, a semi-opaque consistency, which becomes somewhat gelatinous on cooling. Protracted boiling, especially with very dilute Sulphuric Acid, or still better, exposure to a dry heat of about 400°, renders the Starch entirely soluble, converting it in fact into Dextrin or British Gum (×).

Gum.

The nutritive properties of Dextrin and of true natural Gum, represented in our series by Gum Arabic, (×) will be discussed presently, but I may remind you that Gums

vary very considerably in solubility, the best types being perfectly soluble in cold water, whereas those of which Cherry Gum and Gum Tragacanth are examples, (×) only soften and swell up. It is chiefly to substances called *Cerasin* and *Bassorin* that are attributable the properties which thus distinguish a Mucilage, or thickened slime, from a transparent solution of true Gum, the pure chemical principle of which is sometimes termed *Arabin.*

SUGARS PROPER.

The SUCROSES, or *Sugars Proper*, are tolerably uniform in properties, and ordinary Cane Sugar (×) may at present stand for the whole of the sweeteners in common use, matters of detail being reserved for the general review of Food Articles. The only member of this sub-group distinguished by a separate bottle, is *Lactose* or Sugar of Milk (×), which besides a slight chemical difference, is very weak, and seldom employed except for a few medicinal purposes.

GLUCOSES.

The GLUCOSES, or GRAPE SUGARS, (×) though they cannot compete with the Sucroses for culinary purposes, are of great importance as being the sweetening principle of fruits in general, besides forming the saccharine principle of Malt, and consequently of Sweet Wort and Beer. I must leave for the chapter on Fermentation, the curious transition by which Barley and other amylaceous substances have their Starch converted into Glucose, but there is a chemical process by which not only Starch,

but even tough Vegetable Fibre can be similarly transformed. A piece of linen rag has been boiled for some hours with dilute Sulphuric Acid, and the bottle before you contains in a treacle-like form the result, suitably purified (×), which is Glucose, actually more in quantity than the rags employed. This last process, now on the verge of acquiring economic value, is also interesting as confirming the close union between the members of the whole Saccharoid group, of which Cellulose occupies one end and Glucose the other. It is well however to bear in mind that whether Saccharoids are acted on by boiling with an acid, or by a ferment, the change is always in the direction from the first sub-group to the last.*

The foregoing is equally applicable to the changes effected by Digestion, of which the processes considerably resemble those of Fermentation. STARCH undergoes in the short time that it is subjected to the action of the Saliva in the Mouth, a kind of incipient transformation into Glucose, which, checked by the acid reaction of the Stomach, is pursued in the Intestinal Canal under the influence of the juices there united.† It is necessary however that the Starch be in a favourable condition to begin with, for its cells or granules, if not softened or broken up into a mucilaginous state, are apt to resist the digestive process.

* Each transition from an Amylose to a Sucrose, and from a Sucrose to a Glucose, involves the assimilation of an additional atom of Water. The action of Sulphuric Acid in these experiments is rather anomalous, inasmuch as when strong, it has the contrary effect of depriving the Saccharoids of their Water-components, leaving black Carbon.

† See the second Lecture on Physiology, No. 10 of the "Science made Easy" Course.

GUM is evidently placed by its solubility in a different category from Starch, and one might imagine that a clear solution of it would even be readily absorbed by the capillaries of the Stomach and Intestinal Canal, but it belongs to those substances which, as I said before, have been denominated *Colloids* by Graham, who discovered that they pass with difficulty through membranes otherwise open to the diffusion of fluids by Osmosis. On the whole, the amount and nature of its value to the system are still enveloped in considerable doubt and mystery, and it occupies in that respect among the non-nitrogenous constituents of Food, a position somewhat analogous to that held by Gelatin among the nitrogenous ones.

SUCROSE, besides being still more soluble than Gum, for it can actually dissolve in one third of its weight of water, belongs to Graham's class of Crystalloids which have much greater facility for diffusion through membranes than the Colloids, and yet it seems to be seldom admitted to regular circulation in the system. It appears moreover that even if it should gain admittance, it could be to little purpose, for Dr. Carpenter says "if a small quantity of Sugar gain entrance into the circulation, it circulates through the vessels over and over again." The fact is that common Sugar, even when taken in considerable quantity, seldom travels far down the Alimentary Canal before it is changed into *Glucose*, which may indeed be considered as a preferential form into which all Carbohydrates should be converted in order to pass current. The rapidity with which this conversion takes place is so extraordinary, that it cannot be accounted for sufficiently by the action of the Saliva and Pancreatic Juice, and it is supposed that a prompt and still more effective cause of transformation must be looked for in certain *ferments*, or albuminoid substances in a state of incipient decomposition, which are always found in the Alimentary

Canal.* So singularly sensitive is Glucose itself to the power of such ferments, that it is often transformed under their influence into Lactic Acid. This however is not such an extraordinary change as might be imagined, for the difference between Glucose and Lactic Acid depends simply on a splitting of particles.† Much discomfort is sometimes thus occasioned, and to my knowledge one of our most illustrious savants used to be obliged to refrain for a month or more at a time, from taking Sugar with his Tea or Coffee.

Much diversity of opinion prevails as to the form and manner in which the Saccharoids absorbed as Glucose, undergo the process of combustion for which they are evidently designed. Considerable power of argument has been bestowed on the question whether or not they are first converted into Fatty Matter, and the affirmative has been supported by reference to what takes place in herbivorous animals. On the other hand, we are told by Dr. Pavy that such conversion is a matter of comparatively small importance, as whether it takes place or not, the amount of force evolved will be the same.

The peculiar Saccharoid called INOSIN occurs in the Heart and a few other involuntary muscles, and by a curious coincidence it is also found in green kidney beans. It would hardly be worth mentioning, but that its name might erroneously suggest affinity with INOSIC ACID, a

* Considering that the main purpose of the Carbo-hydrates in our system is combustion with a view to Heat and Energy, and that their value as fuel is proportionate to the quantity of Carbon which they contain, it is singular that their absorption should be furthered by a conversion from Cellulose and Sucrose into Glucose, whereby their percentage of Carbon decreases in proportion to the increase of Hydrogen and Oxygen.

† The former has twice as many atoms in its molecule as the latter, namely Glucose $C_6H_{12}O_6$, and Lactic Acid $C_3H_6O_3$, so that a molecule of Glucose may split up into two of Lactic Acid.

nitrogenous compound which serves as a flavorer to Meat.

PECTIN.

It would be a real benefit to the community if indulgence, especially of children, in eating unripe fruit, could be checked by making more generally known how strong is the evidence supplied by Chemistry against this practice. In many kinds, the unripe pulp contained in the cellular tissue, mainly consists of an insoluble and indigestible substance called *Pectose*, mixed with an acid equally injurious. Under the influence of summer heat, the acid acts by degrees on the Pectose, so that in the ripe fruit it is most beneficially transformed into the article of which we have a small quantity preserved in spirit, and which bears the name of PECTIN or VEGETABLE JELLY (×). This remarkable substance is not exactly a Saccharoid, for it is not a Carbo-hydrate, since its Hydrogen is below the proper proportion of the Oxygen* ; but it approximates to the composition of Glucose, and to the consistency of Gum, whilst it surpasses the latter in thickening power, for it possesses in no small degree the peculiar property of gelatinization. It is in fact to this valuable counterpart of Gelatin in the vegetable world, that we owe those jellies, as wholesome as they are delicious, which are prepared by concentrating the sweetened juices of Currants, Apples, Guavas, and other suitable fruits. Pectin may also be obtained for chemical purposes from Carrots, Parsnips, and the like, but the juice of ripe Pears is a more favorite source.

* According to Frémy, its composition may be represented as $C_2H_3O_2$.

ACCESSORY ORGANIC PRINCIPLES.

The Proximate Constituents of Food hitherto reviewed, are not undeservedly called "Necessary Food," for the elimination of any group of them from our Dietaries, would entail, if not a fatal, certainly a very serious injury. Though most wholesome and palatable in mixture, they are all more or less susceptible of being eaten by themselves.—Not so the articles to the consideration of which we are now about to proceed. With one or two exceptions, they have properties too powerful to allow of their being taken by themselves, and indeed they are thus all the better qualified for their main purpose of imparting flavor, or giving life and action to what without them would be insipid or inert. For most of them the title of "FOOD AUXILIARIES" would be very suitable, but not for all. As might be expected, they are far from forming a connected series, but the following arrangement may be found convenient, and has been adopted on our Tablets.

Group 1. Alkaloids.
Group 2. Essential Oils.
Group 3. Alcohol and Ether.
Group 4. Vegetable Acids.
Group 5. Coloring Matters.

Of the members of these five Groups, I will for the present say just as much as may give you a general notion of their chemical nature, mainly reserving their dietetic properties for the description of the substances in which they respectively occur as ACTING or FLAVORING PRINCIPLES.

GROUP I. ALKALOIDS.*

A glance at the Analytical Tablet No. 4 (×), will show you that the articles named in this first Group are all nitrogenous, and at the same time the title of ALKALOIDS given to them, sufficiently indicates that they have a certain resemblance to Alkalies. They all possess in fact the property of uniting with Acids, of neutralizing them, and of forming Salts. In some however that property is very feeble, as for instance in the first on the list KREATINE also spelt CREATINE, and with or without a final *e* (×). It is a crystallizable substance with a slightly bitter taste, found in the juice of meat, and which is generally supposed, notwithstanding its inertness, to add notably to the nutritive qualities of the Fibrin with which it is associated. And yet its proportion in Ox-flesh appears to be only about 20 parts in 10,000. In the flesh of the Common Fowl it is said to reach 32 parts in 10,000, whilst on the contrary Cod-fish, from which it is nevertheless generally extracted, only contains from 9 to 17 parts per 10,000. Kreatine with other kindred substances, one of which bears the name of *Kreatinine*, is supposed to constitute the chief value of pure Beef Tea, and of the so-called Liebig's "Extract of Meat," which must be considered rather as invigorating the action of the stomach, than as substantially satisfying it.† The rather mysterious body Osmazome, which has acquired some chemical notoriety, and gives richness of color, smell, and taste to the brown surface of roast meat, may be considered as resulting partly from the action of Heat

* See "Science made Easy," Lecture VI. Group 6.

† For a discussion of this subject see "Culinary Processes," page 210.

[TABLET No. 4.]

ANALYSES OF VARIOUS ACCESSORY ORGANIC PRINCIPLES.

Group I. Alkaloids.

		C	*H*	*N*	*O*
Kreatine	$C_4 H_9 N_3O_2$	36·64	6·87	32·06	24·42
Kreatinine	$C_4 H_7 N_3O$	42·48	6·19	37·17	14·16
Sarcine	$C_5 H_4 N_4O$	44·26	2·94	41·17	11·76
[Inosic Acid*	$C_5 H_8 N_2O_5$ (?)	31·25	4·16	14·59	49·99]
Theine or Caffeine	$C_8 H_{10}N_4O_2$	49·48	5·15	28·86	16·50
Theobromine	$C_7 H_8 N_4O_2$	46·66	4·44	31·11	17·78
Quinine	$C_{20}H_{24}N_2O_2$	74·07	7·41	8·64	9·87
Morphine	$C_{17}H_{18}N O_3$	71·57	6·67	4·91	16·84
Nicotine	$C_{10}H_{14}N_2$	74·07	8·64	17·28	

* Often associated with the preceding Alkaloids.

on the above highly nitrogenous Alkaloids, and partly from the presence of another peculiar flavorer, INOSIC ACID, a syrupy compound noted for its pleasant meaty taste, and for the agreeable perfume which it and its compounds emit when warmed.

It is not without reason that I use the term highly *nitrogenous* in speaking of Kreatine and its kindred, for as shown by comparing our fourth Analytical Tablet with the first, they contain far more Nitrogen than any of the Food Constituents hitherto considered. Kreatine itself has 32 per cent. and Sarcine as much as 41 per cent. Though the remainder of the Alkaloid Group are of vegetable origin, they all more or less contain Nitrogen. The first of them, THEINE, has nearly 29 per cent. This substance, of which a sample is displayed in the form of slender silky crystals, prone to mat together into lumps (×), is well deserving of careful study, being the chief acting principle of Tea. It is also called CAFFEINE from its performing a similar function in Coffee, and it is likewise found in Maté or Paraguay Tea, the beverage of South America, and in Guarana an astringent kind of Chocolate prepared from the fruit of an African plant.* The fact of its presence in so many articles enjoying in different parts of the world the same reputation for their refreshing and invigorating qualities, might be regarded as a sufficient proof of its merits, even if carefully conducted experiments had not shown that it possesses a peculiar power of diminishing the waste of our tissues occasioned by muscular exertion. Into this important dietetic question, I hope to give you a further insight when we come to the interesting subject of Breakfast Beverages. I will now merely mention a few of the chemical properties of Theine. It has a some-

* The *Paulinia sorbilis.*

what bitter taste, it is slightly soluble in cold water, but is freely taken up by boiling water, it fuses when heated, and at a higher temperature undergoes *sublimation*, or dry evaporation. It suffices in fact to heat some dry Tea in a watch-glass covered with a cone of paper, in order to obtain small crystals of Theine, which if the paper be of a dark color, soon become visible to the naked eye Lastly, it is rather feebly inclined to unite with acids, and the anhydrous crystals that it forms in combination with some of the strongest ones, are apt to decompose when an attempt is made to dissolve them in water.

THEOBROMINE, the active principle of Cocoa and Chocolate, is shown by our Tablet to differ from Theine in having rather less Carbon and Hydrogen, but to have still more Nitrogen. The analogy of its properties is such that a specimen has been deemed unnecessary.

A word of apology may be needed for introducing next on our Tablet, and among the articles in the show-tray, QUININE (×), a substance less agreeable to think of than the delicate stimulants we imbibe in the form of Tea, Coffee, and Chocolate, but not less important to the health of thousands. It is the active principle of that world-honoured antidote for ague and low fever, that proverbially bitter *rind* of certain South American trees, which in recognition of its invaluable services bears, par excellence, the name of *Bark*.*

We shall not be overstepping the natural limits of Hygienic studies, if we bestow a moment's attention on this agent which more perhaps than any other in the whole *materia medica*, bears out the maxim,—"prevention is better than cure," and which, besides being the indispensable companion of a traveller in hot and unhealthy regions, claims connection with the subject of

* Produced by several species of Cinchona, among which the most esteemed is C. calisaya.

Food through the frequency with which it is prescribed as a promoter of appetite, or in other words as a dinner pill. Moreover Quinine being quite as much a representative type of the Vegetable Alkaloids as Theine and Theobromine, it is instructive to note by means of our Tablet, the considerable differences between its composition and theirs, and to be thus reminded of the freedom of action which nature continually asserts in her organic laboratories, combining similarity of properties with diversity of composition, no less than diversity of properties with identity of composition.

Quinine being sparingly soluble in cold water, of which it requires nearly 400 times its own weight, its action on moist Turmeric Paper is feeble, but its salts are numerous and stable, and the Sulphate in particular is a general favorite.

You may have heard of the growers of Madder Root in Alsace and elsewhere, who have been almost ruined through the success obtained by certain chemists in actually compounding in the laboratory, the coloring matter to which that root owes its value. Much ingenuity and perseverance have similarly been directed towards the artificial production of Quinine, on account of the large quantities used, and its high price, but hitherto the endeavours have not proved quite successful, and the philanthropic planters who are rearing forests of Cinchona Trees in the East Indies, have still a fair prospect of reaping the reward which their exertions so well deserve.

Another leading member of the Alkaloid Group to which I must beg leave to draw your attention, is MORPHINE or MORPHIA (×). Like Quinine it can only enter a Food Collection by a side door, for to chew Opium is certainly not to sustain life, but the Hygienist is glad of an opportunity for extolling on the one hand the invaluable services rendered by opium preparations in general,

and by Morphine in particular, in the prevention of suffering, and for deprecating on the other hand in terms of unqualified censure, that unhallowed fascination in which the opium eaters of the East indulge so freely and so fatally.

Like Quinine, Morphine is generally sold in the form of a white powder; though they can both be obtained in small crystals, easily distinguishable from the silky matted ones of Theine. Morphine further resembles Quinine in being less used than its salts, the favorites among which are the Hydrochlorate and the Acetate. Both are soluble, the latter inconveniently so, being slightly deliquescent, whereas Morphine itself requires 1000 parts of cold water, and 400 parts even of hot water.*

There is unquestionably some analogy between the weakness of the opium eater, and that of the man who makes himself the slave of Tobacco, and the active principles of both drugs are stupifying poisons; but beyond this and their alkaline properties, they have little in common. Our Tablet shows that NICOTINE the deadly principle of Tobacco (×), actually contains no Oxygen. Moreover it cannot be crystallized. It presents itself in the form of a volatile liquid, colorless when perfectly pure and fresh, but which very soon contracts a yellow colour, that in time becomes a brownish-red. In virulence it has few rivals, whilst the power and pertinacity of its odour are such, that according to the Belgian records of criminal procedure, they served to bring to justice two murderers who had used it for occasioning the almost instantaneous death of their victim.

* Piperine, an Alkaloid found in Pepper, and which is isomeric with Morphine, would have been placed here, but that it is tasteless and inodorous, so that the honor of being the chief flavorer of our favorite condiment, decidedly belongs to the Volatile Oil, which will be mentioned in conjunction with Essence of Turpentine. Next to the Oil in importance is an acrid resin, soluble in Alcohol.

GROUP 2. ESSENTIAL OILS.

Our second Group introduces a set of bodies celebrated for supplying the choicest perfumes; but what is more to our present purpose, it no less delights the sense of taste with delicious flavors. Most of the flavouring Herbs and Spices used as Condiments owe their virtue to certain VOLATILE or ESSENTIAL OILS, also called ESSENCES, which can be obtained by distillation, as has been done with the specimens selected as types for display.*

You may be surprised to see in the first bottle of this series so unpalatable an article as Turps, or Spirit of Turpentine (×), but independently of the fact that it is not unfrequently an ingredient of Gin, it has a very peculiar chemical claim to be here present. Organic Chemistry informs us that the Essential Oils are mostly composed of Carbon and Hydrogen only, and accordingly belong to that prolific tribe, the Hydro-carbons. Wonderful are the resources of creative power which Nature exhibits in building up with these two elements the most diversified products. It appertains to the Lighting Department of this Museum to demonstrate that a whole series of articles, starting from Marsh Gas, is built up by successive additions of Carbon and Hydrogen in regular proportions, and passes through the liquid Paraffins to the most solid ones; but Turps enlivens our present department with phenomena of isomerism, or identity of composition, still more extraordinary. Round this typical product, consisting as shown by our next Tablet (×) (page 54) of about 88 parts in weight of Carbon to 12 parts of Hydrogen, present themselves a number of articles of exactly the same percentage composition,

* The Essential Oils, often associated with the Alkaloids, as for instance in Tea and Coffee, are best placed next to them as *Acting Principles* in a Food Classification, though otherwise located in a chemical one. See "Science made Easy," Lecture VI.

among which one recognises with surprise, the Essential Oils of Orange Blossoms (commonly called Neroli), Lemon, Bergamot, Thyme, Carraway, Chamomile, Hops, Juniper, Pepper, Ginger, and Cloves (×), which last we have selected as representative.

The Essential Oil or Essence of Peppermint (×), though still a Hydro-carbon, shows as you perceive a slight difference in the proportion of the two elements.

In the next sub-group we see restored the usual triad of vegetable compounds, Carbon, Hydrogen, and Oxygen. It is represented in the show-case by the flavoring agents of Aniseed, (×) Cinnamon (×) and Bitter Almonds (×). The latter affords an interesting example of the other chemical paradox already adverted to, namely,—similarity of properties in bodies of dissimilar composition. The smell and taste of the Oil commonly distilled from Bitter Almonds, Peach-kernels, Laurel-leaves and the like, are marvellously imitated by a body called *Nitro-benzene* (×), produced by the action of Nitric Acid on Benzene, the well known coal-tar product so efficacious in the removal of grease spots. Unfortunately this proposed substitute is as poisonous as the original article, so that its cheapness is rather to be regretted than otherwise.

Another point of interest well worth mentioning in connection with this sub-group, is that, though its members are as a rule perfectly fluid, it includes a substance that cannot be kept in a fluid state at all, for it passes almost at once from the solid condition to that of gas. That substance is the highly useful body Camphor, which as it disclaims connection with Food, I must invite you to inspect in the next class, among the articles used as Preservatives from the ravages of Insects.

There is a very peculiar sub-group of Essential Oils, all identically composed of Carbon and Hydrogen with 28 per cent. of Sulphur ; it includes the Oils of Garlic,

[TABLET No. 5.]

ANALYSES OF ACCESSORY PRINCIPLES (continued).

Group 2. Essential or Volatile Oils.

Hydrocarbons.		*C*	*H*	*N*	*O*	*S*
Oil of Turpentine (Turps)						
,, Orange Blossoms (Neroli)						
,, Lemon						
,, Bergamot						
,, Thyme						
,, Carraway						
,, Chamomile	$C_{10}H_{16}$	88·23	11·77			
,, Hops						
,, Juniper						
,, Pepper						
,, Ginger						
,, Cloves						
,, Peppermint	$C_{10}H_{18}$	87·0	13·0			

Group 2. Essential Oils (continued).

		C	*H*	*N*	*O*	*S*
Oxidised Essences.						
Oil of Aniseed . . .	$C_{10}H_{12}O$ . .	81·08	8·10	...	10·81	
„ Cinnamon . . .	C_9H_8O . .	81·82	6·08	...	12·19	
„ Bitter Almonds .	C_7H_6O . .	79·25	5·66	...	15·09	
[Nitrobenzene . . .	$C_6H_5(NO_2)$.	58·54	4·07	11·38	26·01]	
Sulphuretted Essences.						
Oil of Garlic, „ Onion, „ Leek, „ Cress, „ Radish . .	$(C_3H_5)_2S$ . .	63·16	8·77	...	...	28·07
Oil of Mustard, „ Horse-radish	$(C_3H_5)(CNS)$	48·48	5·05	14·14	...	32·32

Onion, Leek, Cress, and Radish. To these may be associated the Oils of Mustard (×) and Horse-radish, which further contain Nitrogen. Most of them, and the two last mentioned in particular, have certain intricacies of composition which render their analysis troublesome, but which may be left to the chemical student.*

The leading features of the Essential Oils may be briefly summarised as follows:—Their *Specific Gravity* ranges mainly from 83 to 100, that of Water, whilst a few, including Oil of Cloves, slightly exceed it. *Volatility* is so characteristic a feature that they are called "Volatile Oils," in contradistinction to the "Fixed" or "Fatty Oils." A convenient criterion is afforded by this property for ascertaining whether expensive Essential Oils are adulterated with fatty ones. A stain on a piece of blotting-paper will, when held to the fire, completely disappear if the Essence be pure, but partially remain if there be a fatty admixture.—Camphor melts at 347°, and boils at a very slightly higher temperature, while it gradually sublimes at a much lower one. Essential oils are very *combustible*, but burn mostly with a lurid and smoky flame, though the flame of Camphor is clear and brilliant. The *antiseptic* properties of the Essentials Oils are well known. The *dietetic* effects will be dealt with in speaking of the special Condiments to which they belong. Thus much however may be said in a general way, namely, that even the best of them are easily rendered injurious by immoderate use, and that the abuse of stimulants is considered by foreigners to be one of the chief defects of English cookery. I need scarcely allude to the effects of strongly-scented flowers in bed-rooms.

* Oils of Mustard and Horse-radish mainly consist of a Sulphocyanide of the peculiar Hydro-carbon, Allyl (C_3H_5). The other sulphuretted oils above mentioned are mainly Sulphides of Allyl.

GROUP 3. ALCOHOL AND ETHER.

The chemical history of ALCOHOL, or SPIRIT OF WINE, will be a part of that of Fermentation ; its dietetic history will be that of the liquors which contain it. I will therefore only give a few particulars which will be best remembered through being now taken by themselves.

The crude Spirit obtained by distillation from the various sources to be described hereafter, becomes on being carefully re-distilled, *Rectified* Spirit, and this on being again distilled from Quicklime, yields *Absolute* Spirit, that is to say, Alcohol absolutely deprived of Water (×). It is to this product that apply the formula and percentage composition given on our Tablet (×) (p. 59). You will at once remark that Alcohol is in a high degree Carbonaceous, containing more than 50 per cent. of Carbon, to say nothing of over 8 per cent. of free Hydrogen, that is to say of Hydrogen over and above the quantity neutralised by the associated Oxygen. Its Specific Gravity at ordinary temperatures is about 79, water being 100, whereas that of common *rectified* Spirit lies between 80 and 90. The name of "*Proof* Spirit" is given by the excise authorities to Alcohol of a Specific Gravity of 91·9, which contains rather under 50 per cent. of pure Alcohol. Every half per cent. of absolute Alcohol added, raises the Spirit "one degree above proof."

Closely connected with Alcohol is ETHER. Of this product there are many kinds, but the one had in view when that name stands alone, is *Sulphuric Ether* (×), prepared by distilling Alcohol with Sulphuric Acid at a temperature between 284° and 290°. It is one of the lightest fluids known, its Specific Gravity being only 72.

The value of Ether is incontestable, whether taken

liquid as a sedative, inhaled in vapor as an anæsthetic, or applied outwardly as a refrigerative. This latter use depends upon the extreme readiness with which it passes into vapor, its boiling-point being as low as 96° F. (35·5° C.). It is also on this property that Dr. Richardson founded his discovery of its employment as a local anæsthetic, projected in fine spray on parts to be subjected to surgical operations. All this makes me regret the more that I must now mention Ether in connexion with mischief. There are persons who instead of using it externally, actually drink it as a mild and fugitive stimulant, whilst others resorting to its more frequent use, lapse into a melancholy state of drowsy stupefaction.* The uncontrolled and careless employment of Ether is the more to be deprecated, as its volatility, and the liability of its vapor to ignition by a light at some distance from the vessel containing it, are apt to cause explosions that scatter liquid fire in all directions.

GROUP 4. ORGANIC ACIDS.†

Through one of those transformations which one gets so accustomed to in Chemistry that they cease at last to appear marvellous, Alcohol by a slight change in the proportions of its constituents (see Tablet No. 6) becomes ACETIC ACID, (×) the Acid of Vinegar. We shall see in the section on "Fermentation" that good salad Vinegar is nothing but a weak quality of this

* The extent to which *Ethereal* intoxication was at one time carried on in Ireland, may be gathered from a paragraph in Johnston's "Chemistry of Common Life" referring to an article by Dr. Richardson in the 'Gentlemen's Magazine' for October 1878.

† See "Science made Easy," Lecture VI. Group 5.

[TABLET No. 6.]

ANALYSES OF ACCESSORY PRINCIPLES (continued).

Group 3. Alcohol and Ether.

	C	*H*	*O*
Common (Ethyl) Alcohol (C_2H_6O)	52·17	13·04	34·78
„ (Ethyl) Ether ($C_4H_{10}O$)	64·86	13·51	21·62

Group 4. Acids.

	C	*H*	*O*
Acetic ($C_2H_4O_2$)	40·00	6·66	53·34
Citric ($C_6H_8O_7$)	37·50	4·13	58·35
Malic ($C_4H_6O_5$)	35·82	4·47	59·70
Tartaric ($C_4H_6O_6$)	32·00	4·00	64·00
Oxalic ($C_2H_2O_4$)	26·66	2·22	71·11
Tannic ($C_{14}H_{10}O_9$)	52·13	3·12	44·75
Lactic ($C_3H_6O_3$)	40·00	6·66	55·34
Butyric ($C_4H_8O_2$)	54·54	9·09	36·36

Acid obtained from Wine, Sweet-wort, and other saccharoid articles that have fermented into sourness, retaining slight distinctions of flavor and color. It is true that a much stronger quality of Acetic Acid is obtained by the destructive distillation of Wood, but it should only be used for adding sharpness to Pickling Vinegar. *Absolute* Acetic Acid, that has like *Absolute* Alcohol been entirely deprived of its watery accompaniment, is called *Glacial*, because below a temperature of 60°, which is by no means of uncommon occurrence, it congeals into crystals like flakes of ice. When fluid, its Specific Gravity is rather above that of water, namely 1·063. Its boiling-point is 248°. Its power is such as to occasion an almost immediate blistering of the skin, and ordinary table Vinegar does not contain more of it than about 4 to 6 per cent. It is somewhat paradoxical to say that sharp Acetic Acid and sweet Glucose have the same percentage composition; yet this is an incontestable fact, as may be seen by comparing our 3rd and 6th Tablets.

Acetic Acid is the chief liquid acid in our selection, the others being mostly solid, and the crystallisation of nearly all of these sufficiently well marked to aid in their recognition. Their arrangement in chemical order would involve too many explanations, so I will take them in the order of importance.

As Vinegar has its triumph in Pickles and Salads, Lemon Juice, thanks to its CITRIC ACID (×), stands pre-eminent in the production of refreshing drinks, and generally wherever the object is an agreeable blending of sour and sweet. Apart from this, there is Citric Acid in the fruit of the Lime, the juice of which has been found invaluable for the prevention of scurvy in protracted sea voyages.

The piquancy of Citric Acid, extreme in the Lemon,

and deliciously tempered in the Orange, is emulated by MALIC ACID (×) in numberless fruits besides the Apple, from which it derives its name. I may mention that sometimes Citric, or some other Acid, comes to its assistance, but need not follow out the endless varieties of taste produced in succulent Fruit, by gradations from unripeness to maturity, from acerbity to lusciousness, and from insipidity to high flavor or delicate aroma.

Though there is scarcely a juice of milder character than that of the Grape, its special acid, TARTARIC ACID (×), is when pure too powerful to be agreeable to the palate, even though veiled with sugar; but the form in which it is gradually deposited in the wine cask, is that of Tartrate of Potash, and this salt, which is commonly known as "Cream of Tartar," has just enough acidity to produce with sugar a very agreeable, as well as wholesome drink. This is moreover the Acid used to dislodge the Carbonic Acid of Bi-carbonate of Soda in producing the popular effervescing drink with Soda-water powders.

Sharpest of all the Vegetable Acids is OXALIC ACID (×), so named from the *Oxalis*, or Wood Sorrel, from which it used to be extracted before chemical means were discovered of actually producing it from Sugar, and even from Sawdust. Not only is it a virulent poison, but even the salt which like Tartaric Acid it forms in combination with Potash, and which is often used for cleaning brass, is too dangerous to be taken inwardly. And yet it is this very salt which gives flavor and dietetic value to the leaves of the Garden Sorrel (*Oxalis acetosella*) of which such wholesome use is made on the Continent. In conjunction with Malic Acid, it gives welcome sharpness to garden Rhubarb, the refreshing ingredient of "spring" tarts.

The fawn-coloured powder in the next bottle is TANNIC ACID (×), an acid so feeble that its acidity

remained for a long time unobserved, so that it used to be simply called *Tannin*. I mentioned in a previous section, the peculiar efficiency of Tannic Acid as a test for Gelatin, in combination with which it forms the substance so well known as *Leather*. The account of this article belongs to another department of Domestic Economy, but it may be well to draw attention to the undesirableness of mixing in the stomach, gelatinous broths or jellies, with liquids containing Tannic Acid, such as Tea that has grown strong through standing long enough to dissolve this astringent and constipating principle, of which it sometimes contains nearly 20 per cent.

It may be well to mention here a few acids of an altogether unwelcome character, produced by the deterioration of Food Articles. Thus LACTIC ACID (×), of which the percentage composition like that of Acetic Acid, is identical with that of Glucose though built up differently, is the undesirable result of a metamorphosis which that substance is only too prone to undergo under the influence of fermenting agents of frequent occurrence among the fluids of the Intestinal Canal.—A further stage of the same Fermentation produces a peculiar compound, BUTYRIC ACID (×), which appears to be also one of the offensive acid vapors that result from the over-heating of Fat in certain culinary processes.*

Far more dangerous than any of these, yet concealing its virulence under the mask of a fragrant odour and a palatable flavor, is HYDROCYANIC ACID better known as PRUSSIC ACID (×), which occurs in the leaves of the Common Laurel (*Prunus laurocerasus*), the kernels of the Bitter Almond, the Peach, and other allied fruits, the root of the Bitter Cassava, and other sources. The

* Other Fatty Acids resulting from the above causes, such as Capric Acid and Caproic Acid, have not been thought worth exhibiting.

objectionableness of using it, even in the form in which it flavors and scents the oil commonly distilled from Bitter Almonds, has been alluded to in speaking of the Essential Oils. The association of this deadly poison with some of our most valued starchy foods in the plant from which they are derived, will be mentioned in reviewing Tapioca and Arrowroot.

GROUP 5. ORGANIC COLORING MATTERS.*

The articles of this description commonly and legitimately used in Food, are neither numerous nor important; still it may be well to devote a few words to them in recognition of their superiority, from a hygienic point of view, over the coloring matters of metallic origin, and others equally injurious, which will be pointed out in speaking of special adulterations.

The most deserving of notice is CHLOROPHYLL (×), that peculiar and mysterious substance which gives to leaves of plants their green color, and appears to exercise no inconsiderable influence on their functions. It is soluble in Alcohol and Ether, and its solutions exhibit the singular phenomenon of appearing Green to the person who looks through them towards the light, and Red to a person who looks at them from the light. Chlorophyll has of late been so successfully prepared from Spinach and the like, as to serve for coloring pickles and other similar articles, for which copper solutions are but too commonly used, but it is scarcely obtainable in this country, nor has its chemical composition been as yet accurately ascertained.

ANATTO or ARNATTO (×), a paste prepared from the

* See "Science made Easy," Lecture VI. Group 7.

pulp surrounding the seeds of the *Bixa orellana* is brought in considerable quantities from the tropical regions of America, for being used to impart a rich yellow color to Cheese, and sometimes to Butter, without detriment to taste ; we shall accordingly see it again in the review of the Dairy Department. The chief coloring principle, which is a resinous substance of an orange-red hue called *Bixin*, is never used in its isolated state.

TURMERIC (×). Analogous to Bixin is *Curcumin*, the coloring principle of Turmeric the dried root of the *Curcuma longa*, an Indian plant. Powdered Turmeric is much used for curry powders and the like. It is the same article which serves to stain the paper used for detecting Alkalies, these having the property of turning its yellow to a reddish brown.

SAFFRON (×), used in the South of Europe for imparting a delicate yellow hue and agreeable flavor to soups, pastes, confectionery and liqueurs, is a rather expensive article, for it consists only of the stigmas and part of the style of the Saffron Crocus, 60,000 flowers of which are said to be required for yielding a pound of this dainty article. Its reputation as an antispasmodic and exhilarant, appears to have faded away. Its coloring principle *Crocine* is never seen.

It may be useful to know that ORCHIL (×), a splendid purple color derived from certain Lichens, but of which the preparation used formerly to be objectionable, is now obtainable by a cleanly process which fits it for alimentary use. Its coloring principles are too intricate for explanation.

As far as I am aware, the only coloring matter of animal origin used in cookery is that called COCHINEAL (×), being a solution prepared from the famous little beetles (*Coccus Cacti*) of the Indian Fig. Its coloring principle *Carmine*, has certainly a most brilliant

scarlet hue, and its tinctorial power is prodigious, but I must say that I should prefer to eat jellies colored with the liquor of beet-root, or blue cabbage.*

It is quite a different thing to boil copper pennies with Peas in order to give them a brighter green, or to put them in Vinegar to enhance the colour of green Pickles, or to use Sulphate of Copper for brightening the hue of Green Tea. Nor are these by any means the only reprehensible devices of this kind, as may be seen by the following list of forbidden coloring matters, abridged from a Notice lately addressed by the Prefect of Police of Paris to confectioners, distillers, grocers and shopkeepers generally :—

The compounds of Copper including blue verdigris and mountain blue.—The compounds of Lead, including its oxides, oxychlorides, chromates, and carbonate.—The compounds of Arsenic, including Scheele's Green.—Sulphide of Mercury (Vermilion).—The forbidden Organic Coloring Matters include several Aniline compounds and their Nitro-derivatives.—The caution enjoined rightly extends to the coloring of wrapping papers and the like.

* Properly speaking, Carmine itself owes its peculiar color to its chief constituent, Carminic Acid.

CHAPTER II.

INORGANIC OR MINERAL COMPONENTS OF FOOD.

ASH.

We shall find, as convenient as it is natural, to separate the Proximate *Inorganic* Constituents of Food into two divisions: Solid and Liquid. In the *Liquid* division we shall find Water reigning supreme, for the greatest infringement on its authority does not go further than detach a mere fraction of its rights in favor of Alcohol. Something similar occurs among the *Solid* Inorganic Constituents of Food, for Common Salt well deserves a special monograph ; whilst all the rest can be sufficiently dealt with in a cursory review, to which I will at once proceed.

Inorganic bodies are generally speaking easy to identify when combined among themselves, but when they are associated with organic substances, the task of determining the exact conditions of the union is often a difficult one. Hence a practice, more convenient than satisfactory, which we shall find to be very commonly resorted to in analyses of food articles, that of *Incineration.* A portion of the substance under investigation is heated till the organic matter is burnt away, and nothing remains but an undefined mixture of the inorganic constituents in the form of Ash. One of the bottles in our

show-tray No. 2 contains a residue of this description, obtained by submitting a vegetable substance to the process of cremation (×). It is inscribed "Vegetable Ash." The "Animal Ash" in the next bottle (×) is derived from that part of the animal system which yields by far the greatest amount of residue on incineration, namely, the Bones.

Those of you who are conversant with Anatomy will remember that in a man of normal stature weighing about 154 lbs., the Skeleton, comprising about 200 bones, may be reckoned to weigh on an average 24 lbs. Bones consist of a netted or spongy structure of Gelatin, of which the meshes contain a deposit of earthy salts. Now these salts reduced to Bone-ash by burning away the Gelatin, are found to amount to over 60 per cent. of the weight of the bones employed, or 16 lbs. out of the 24. Of this amount, over 12 lbs. consist of Phosphate of Lime, the earthy salt contained in a third bottle (×), whilst about 2½ lbs. consist of Carbonate of Lime, represented by Chalk (×).* The remaining pound and a half of Bone-ash may be considered as made up of Fluoride of Calcium (×) and Phosphate of Magnesia (×), with a little Oxide and Chloride of Sodium.†

* Sulphate of Lime does not appear to be a constituent of the Human Body, nor to be of frequent occurrence in Vegetable Ash. It is accordingly reserved for the subject of Drinking Water, among the mineral impurities of which it occupies a conspicuous position.

† The following is the average composition of Dry Bones according to Kingzett ("Animal Chemistry," p. 332).

	Per cent.
Water and Ossein	30–34
Phosphate of Lime	45–52
Carbonate of „ „	6–14
Fluoride of Calcium	1–2
Phosphate of Magnesia	·8–1·2
Other Salts containing some Chloride of Sodium	traces.

The Mineral Matter contained in the other portions of the human body, though perhaps trifling compared with that found in the bones, is nevertheless far more generally diffused among its solid and liquid materials, more closely combined with them, and more essential to the maintenance and active manifestation of the phenomena of life, than is commonly supposed. Independently of a certain amount of Common Salt diffused throughout the body, Phosphate of Lime itself is affirmed by the best authorities to be actually present in every tissue or structural element and singularly enough to be particularly in demand where a lively growth and multiplication is going on among young tender cells.

Some idea of the peculiar distribution of Mineral Matter in various parts of the human frame may be gathered from the following indications. They are borrowed from a passage in Johnston's interesting "Chemistry of Common Life," in which he states what each part of the body takes from the Blood.—To the Phosphate of Lime demanded by the Bones, the Cartilages appear to prefer Phosphate of Soda (×). The Muscles borrow Phosphate of Magnesia, already shown, and Phosphate of Potash (×). Silica (×) is nearly monopolised by Hair, Skin and Nails ; Iron (×) occurs in the Hæmatin or coloring matter of the Blood, and it is inferred by some that the readiness with which its oxides take and give Oxygen may have something to do with the remarkable alternations of scarlet and purple in arterial and venous Blood. Sulphur (×) exists in the Hair to the extent of from 3 to 5 per cent. and may be partly answerable for the extremely unpleasant odour of burnt hair. Prof. von Bibra has even discovered as much as 8 per cent. in some specimens of red hair. Lastly, Phosphorus (×) has its special dwelling-place in the fatty matter of the Brain, whilst it is also a constituent of the nerves.

In thus investigating the Mineral Ingredients necessary for the construction and maintenance of our frame, we are led to appreciate the debt of gratitude we owe to plants for every resource of our store-room and larder. It is they who collect and elaborate from the saline juices of the earth and the gaseous offerings of the air, not only their own direct alimentary tributes, and the valuable ones transmitted through the instrumentality of animals, but also the Mineral Accessories we require. In some degree the saline products which plants contain are determined by the supplies among which they live. Thus for instance, a maritime species like Sea-kale will almost invariably yield salts of Soda, whilst an inland one like Spinach, may be expected to yield salts of Potash; but to a far greater extent the various plants exercise as it were their own intelligent discretion in the selection of saline matter. The results are conveniently varied, and a careful study of them affords valuable guidance in devising those regulations for effecting in our meals an intelligent compromise between requirements and resources, which are called *Dietaries*. You will form some idea of the disastrous effects of the want of attention to these regulations, when I state that the absence of certain Alkaline Salts, notably Acetates, Tartrates, and Citrates, which exist chiefly in fresh Vegetables, may induce that state of malnutrition, which in its higher degrees, we call Scurvy. A deficiency of Phosphate of Lime in the food of children, has been said to result in that weakness of the bones which goes by the name of "Rickets." We cannot in this latter respect be too thankful to Casein, and its vegetable analogue Legumin, which possess so remarkable a capability for taking up Phosphate of Lime, and bringing it unperceived into our system. The presence of Casein in Milk is one of the

many circumstances which concur to render that fluid so pre-eminently capable of supplying all the wants of infancy. Milk indeed is the only type of Food, of which it can be said that it "is complete in itself." It is true that the Yolk of Eggs contains Phosphorus, but it has been rightly remarked that our Bones do not get the benefit of it as do those of the young Chick. We eat the Egg fresh without the shell, but during incubation the Phosphorus becomes oxidized, the Phosphoric Acid thus formed, in order to produce the Phosphate required for a bony structure, combines with a portion of the Lime of the shell, and the latter becomes easier to break in proportion as its inmate acquires strength to break it. Liebig remarks in respect of bone-producing, if we wish to put Eggs on a par with Milk, we must eat the shell as well as the contents. Sulphur is also a constituent of the yolk of Eggs, as is clearly proved by two unpleasant properties which that valuable food-article unfortunately possesses, viz. the blackening of Silver through the formation of a dingy Sulphide of Silver, and the diffusion when stale, of Sulphuretted Hydrogen Gas, well known as the herald of rotten Eggs. Peculiarity of smell, and that mostly a disagreeable one, seems to form a connecting link between most substances in which Sulphur occurs. Examples of this are afforded by Garlic, Onions, Assafœtida and the like; I will not add Mustard, for its smell is rather pungent than offensive.—I mentioned that Silica the formative principle of Sand and Pebbles, is contained in our hair, skin and nails. The quantity is however very small, and among the products which supply it, I need only mention the Cereals, more especially Oatmeal. Iron, which being present in the Blood may be said to be everywhere in our body, is almost as ubiquitous in our Food resources, though in minute proportion, and not perceptible to the

palate, except when it flavors the water from certain springs.*

The following are the percentage proportions of Mineral substances in a few common articles of Food, calculated from data in Parkes' "Practical Hygiene" (p. 196).

	Per cent.
Rice	·51
Milk	·59
Potatoes	1·02
White Fish	1·02
Eggs	1·02
Poultry	1·18
Bread	1·28
Fresh Beef	1·60
Peas	2·28
Butter	2·69
Dried Bacon	2·89
Oatmeal	2·97
Cheese	5·38
Salt Beef	21·09

Salt.

I stated at the beginning of this chapter, that among all the Inorganic or Mineral Components of Food, one only, namely, COMMON SALT, or CHLORIDE OF SODIUM, would stand out so pre-eminently as to deserve being made the subject of a special monograph. It is not on account of any predominance in our system, for of Phosphate of Lime, the main earthy constituent of our Bones, there are more than 12 lbs. in the Skeleton alone, whilst of Common Salt, only mere traces are found in the Bones, and according to Prof. Church, the quantity in the whole body does not amount to more than 7 oz.

* For further particulars concerning the mineral constituents of our body, see again its Ultimate Analysis in Appendix I.

But the quantity of Salt with which under normal circumstances, nature requires that we should supply our system, partly for well-defined purposes, and partly for purposes very imperfectly understood, is beyond comparison greater than might be inferred from its permanent amount. Then again whereas most of the other mineral components of our frame are, as has been shown, supplied without our being aware of it, as inseparable ingredients of our daily aliments, Salt on the contrary, is a necessary item in the list of things which we must constantly provide, and which we therefore appropriately call *Provisions*. It does not compete in nutritiveness with the Organic Constituents of Food, but it is unquestionably the most essential of all Condiments. Its history dates from remote antiquity; it has been conspicuous in sacrifices, and among many nations it still claims reverence as the hallowed type of hospitality. As regards abundance, it surpasses in quantity all other soluble ingredients of our globe. The immeasurable waters of the Ocean contain rather over 4 ounces of Salt in every gallon,* whilst in many regions vast reserves are stored up between the other strata of the earth's crust in solid beds, which when sufficiently pure to be worked for direct use, are called *Rock-salt.* (×) The deposits which most directly concern us are the Salt Mines of Cheshire, where the Rock-salt forms a bed a mile and a half long, 900 feet broad, and 60 feet thick; but even this gigantic mass dwindles into insignificance when compared with the Polish Salt Mines of Wielitzka, of which the strata extend 500 miles in length by 20 miles in breadth, and are no less than 1200 feet in thickness; so that to use the words of Prof. Miller, "They contain sufficient salt to supply the whole world for ages."

* More correctly 2·7 per cent., producing a Specific Gravity of about 1·0274 at 60° F.

Chemical and Physical Properties.

Viewing Salt from a chemical stand-point, we notice in it the leading type of those Binary Compounds which from the Greek name for Sea-salt have taken the title of *Haloid* Salts. Thus Common Salt, after having borne successively the names of Muriate of Soda, and Hydrochlorate of Soda, has become Chloride of Sodium, and Sodium Chloride, or Sodic Chloride.* Its anhydrous crystals, which are of a cubic form as seen by the specimen in our show-case inscribed *Sal-gem* (×), are not often of a large size, but may be had so transparent that they have actually served to form lenses. It has a peculiar aptitude for the transmission of heat-rays, and an eminent physicist pronounced it to be for them, what glass is for rays of light. It dissolves in about 3 times its weight of cold water, and against the ordinary rules of saline substances, its solubility is but slightly increased by using boiling water.† Accordingly it is not obtained in its crystallised state by allowing a hot saturated solution to cool down, as is the case for instance with Alum, but its solution called *Brine* (×) must be evaporated, —slowly, if crystals of any appreciable size are desired, as in the coarse variety used for salting Fish and the like (×), and rapidly, if one wishes to have a fine grained Table-salt (×). Both kinds are produced by artificial heat from the Brine obtained in the Cheshire Salt Mines, and other similar ones, either through the action of water trickling down the surface of the saline rock,

* Formula $NaCl$, or Sodium 23, Chlorine 35·5; or Sodium 39·3 per cent., and Chlorine 60·7.

† Water at 32° dissolves 35·5 per cent. of the Salt; at 229°, the boiling-point of the saturated solution, it dissolves 41·2 per cent.

or by steeping portions of the latter in appropriate reservoirs. Some of these in the mines near Salzburg are large enough to take the name of subterranean lakes, and to be traversed in boats by torchlight by gentlemen and lady travellers, attired in a peculiar costume, and impressed with feelings of uncomfortable amazement.

Some ingenuity is displayed in utilising natural agencies to supplement or economise artificial heat in the production of Salt from sea water, or land brine. In warm regions, as for instance in the south of France and on the coast of Portugal, the sea is let into extensive lagoons, where it is subjected to the heat of the sun till crystallisation ensues. On the contrary in regions where the winter cold is excessive, advantage is taken of the fact that sea-water in freezing leaves its Salt behind, the ice formed being nearly pure water, whilst the Brine is proportionately concentrated. In countries where neither extreme of temperature is available, Brine insufficiently charged with Salt, is pumped to a height and allowed to fall on faggots, or other contrivances for offering a great extent of surface to the air, whereby concentration is effected before heat is applied.

The rough Sea-salt, or *Bay-salt* as it is called (×), is either used in its coarse but agreeably pungent state, or re-dissolved and purified into white Salt (×). The specimen named "English Bay Salt" (×) is obtained by artificial heat, retaining for the purpose of inland bathing certain ingredients of the sea Water which contribute to render real sea bathing so invigorating. These ingredients include Chloride of Magnesium, of which there is sometimes as much as 3·66 parts per 1000 of sea water. It is this substance that mainly gives to Bay-salt its sharp flavor, and causes a marked tendency to deliquescence, observable also in some other varieties. Pure Chloride

of Sodium is but slightly deliquescent in moist, and not at all in moderately dry air. In some samples, Chloride of Calcium is present in small quantity. Other salts of Lime occur in most sea waters, but not so abundantly as in fresh-water. The Iodides and Bromides though in very small quantity, may not be without effect in the beneficial influences of sea-bathing.

The relative proportions of the various saline ingredients of sea-water may be gathered from the following analysis by Riegel of a sample taken off the coast of Havre. It is borrowed from Johnston's "Chemistry of Common Life."

	Parts per 1000 of Sea-water.
Chloride of Sodium	34·632
Chloride of Potassium	·307
Chloride of Calcium	·439
Chloride of Magnesium	2·564
Bromide of Magnesium	·147
Sulphate of Lime	1·097
Sulphate of Magnesia	2·146
Carbonate of Lime	·176
Carbonate of Magnesia	·078
	41·586

For further particulars respecting Salt-water, see Appendix No. III.

Physiological Action.

It is rather unfortunate that the physiological action of Salt, the point which interests us most, is precisely that about which we seem to be least well informed. That it should be necessary to the existence of marine plants and animals is natural enough. That it is essen-

tial to a healthy condition of land animals, including ourselves, is emphatically demonstrated by the well-known craving for it; a craving which Geologists assure us to be no mere modern fancy. They tell us that the antediluvian beasts that browsed in the American wilds, used to resort to certain swampy regions for the sake of a saline formation called the "Salt-licks," where they sank in and perished, leaving their huge bones to tell the tale. Independently of this craving, actual experiment has shown that deprivation of Salt entails as a rule suffering and disease. With cattle, the first symptom of disturbance manifests itself in the coat, the hair of which instead of being smooth and shining, becomes dull and erect. At the same time the whole demeanour of the beast denotes diminished vigor and animation. With man, the results have in many instances been deplorable; and yet there are strange exceptions to the liking for Salt. For instance, Johnston in his interesting article on this subject, ("The Chemistry of Common Life,") mentions a tribe of South Western Africa, the Damaras, that never take Salt, and affirms that most of the Russians of Berezov in Siberia, show a similar disregard for it, whilst a certain tribe of New Zealanders hold Salt in abhorrence.

Such exceptions as these cannot however invalidate the general importance of Salt as a *Condiment*, in which capacity it is almost as indispensable a flavorer of savory dishes, as Sugar is of sweet ones. The question is what are its functions in our system? The most satisfactory answer is that given by the Stomach. It could not well perform its wonders of digestion, if it were not aided by the Hydrochloric Acid contained in the Gastric Juice, and which we must suppose to have been obtained through the decomposition of a proportionate quantity of Salt. How so strong an affinity as that of Chlorine

for Sodium can be overcome without any agent comparable to these in chemical energy, is beyond our comprehension, and we could scarcely believe the fact, if we had not become accustomed to see the influence of Vitality constantly bringing about mutations in which the powerful seems conquered by the feeble.*

Whilst Hydrochloric Acid is added to the Gastric Juice, Soda is rendered available for new combinations. Thus united with certain acids engendered by the Liver, it forms peculiar salts found in the Bile, whilst other Soda Salts appear to be singularly conducive to a healthy growth of Cartilage.

Independently however of the materials which it supplies, Salt itself occurs in notable quantity in the serum of the Blood, namely about 3 per 1000 in Man, and about 4 in Woman, which amount surpasses that of all the other salts put together. The persistency with which this quantity is maintained under diets varying considerably as to the quantity of Salt they supply, is very singular, and goes far to prove that this ingredient must have some definite purpose to fulfil, however difficult it may be to state precisely what that purpose is.

Dr. Carpenter in his "Principles of Human Physiology" says simply, "it is needed for the conservation of the organic components of the Blood in their normal condition." Liebig who appears to have paid much attention to this question says, "Salt serves in the organism to assist and promote the general changes, without taking a share by its elements in the formative process." He further notices the peculiar fact that "no

* It is worthy of notice that a very small quantity of Hydrochloric Acid, not exceeding one part in 1000 of water, suffices to exercise a powerful dissolving action on the Albuminoids, whereas the same acid of moderate strength has the effect of again precipitating them. A solution of three per cent. of Salt has the same coagulating effect.

organised part or tissue contains Chlorine in chemical combination, but there is no fluid of the animal body in which Chlorine is absent as a constituent."

Further on he attributes to the consistency which Salt gives to the Blood, an osmotic action by which water is absorbed into the system with peculiar facility. This is confirmed by Lankester, but much still remains open for investigation.*

* The fact that a solution of Sodium Chloride, like that which forms part of the Blood, does not exude freely through the Membranes which contain it, but that by osmotic action, it attracts water from without, may possibly serve to account for the uniform degree of dilution which the Blood maintains under normal circumstances, and which might soon be destroyed if its fluid portion could ooze out, leaving behind a thickened magma of corpuscles. Again the same osmotic action may have the effect of drawing into the saline currents of the lymphatic system, thin aqueous humours, which might otherwise accumulate with a dropsical tendency. It is not without reason that Liebig draws attention to the circumstance that "Common Salt possesses the property, quite unusual among Salts, of forming with Urea a chemical compound, which crystallises in large clear rhombic prisms." Now considering that a large quantity of Urea is constantly being formed in the muscular system through the decomposition of its nitrogenous fibres, and that this Urea might before reaching the Kidneys injuriously taint the Blood, if a counteracting influence were not at hand, the question arises whether that salutary influence may not be exercised by the Sodium Chloride, with which the Urea as soon as formed enters into innocuous combination.

Water.

PHYSICAL PROPERTIES.

Water is as indispensable a factor in the economy of our existence, as it is in that of the Globe on which we live, so that there is scarcely a science with which it is not more or less connected.—Elementary Physics points to it as the great type of Liquidity, manifesting a looseness and slipperiness of particles, which render it marvellously adaptable to every form, and obedient to every impulse. Hence its subserviency to certain Hydrostatic Laws from which we derive incalculable benefit, to say nothing of the influence they exercise on the general character of the Earth's surface.*

Water in "*seeking the lowest level*" forms streams, which whilst they furnish us with water-power, cut valleys in the high lands, and carrying with them the products of their erosion, supply sediment for new geological formations in the bosom of that vast Ocean which Geography shows us as occupying at least three quarters of the surface of the Globe. Then the key to nearly all the wonders of our modern Water-supply system, lies in the law that "*Water always seeks its own level.*" Again it is equally to the properties that attach to liquidity, that we owe on the one hand a convenient means of determining specific gravities, and on the other hand the comparative ease with which floating bodies of appropriate form, can be impelled, in other words, the marvels of that Navigation by which a continuous supply of

* For elementary notions of Hydrostatics, see "Science made Easy," Lecture III.

Food is secured to countries which like ours abound more in manufacturing population than in agricultural supplies.

Water as a Standard.

You are aware that the density of pure Water, that is to say, of Water carefully distilled, or of clean rain-water, at a temperature of 60°, is the generally adopted standard for the Specific Gravity of Solids, as well as for the Density of Liquids. In the French Metrical System, water is further made to constitute an accurate link between Capacity and Weight. The *Mètre*, or Meter, founded on geometrical calculations, having been adopted as the standard of linear measurement, a cube of one Decimeter was fixed upon to form the standard of capacity under the name of *Litre*, and a Litre of distilled Water at its maximum of density, i.e. 4 degrees Centigrade above Zero, was declared to weigh a *Kilogramme*, or one thousand *Grammes*, a cubic *Centimetre* supplying the unit of weight, i.e. one Gramme or Gram.

The English systems of Weight and Measurement do not stand in so convenient a relation with Water, nevertheless the following data may be of service.

One cubic inch of Water at 62° F. weighs 252·452 grains.

One cubic foot = nearly 1000 oz. av.

In the pharmaceutical measurement of capacity, the unit is the Minim. One Minim of Water weighs ·91 grains.

Sixty Minims, or one fluid Drachm of Water weigh 54·68 grains.

Eight Drachms or one fluid Ounce of Water = 437½ grains.

Twenty fluid Ounces, or one Imperial Pint = 8750 grains.

Eight Pints or one Gallon = 70,000 grains or 10 pounds.

One Drop may be considered as approximately equivalent to one Minim.

One Tea-spoonful is rather over a fluid Drachm.

Four Tea-spoonfuls rather exceed one Table-spoonful.

These last three measures must of course be considered as very unreliable.

WATER IN RELATION TO HEAT.*

The most lively of the phenomena exhibited by Water, are those which it manifests in connexion with Heat, undergoing that ever-recurring cycle of transformations which affords such constant occupation to the Meteorologist, and of which the Hygienist must never forget to take account. Ascending from Earth and Ocean as invisible vapour, a portion descends again equally invisible, till its presence is revealed by sparkling dew-drops, or silvery hoar-frost, but the greater part floats for a time high in the atmosphere, with a variety of form and colouring on which the eye delights to dwell, and a variety of physical consistencies which the mind can as yet scarcely realize. Equally unaccountable are often the causes which determine its fall in various forms, from the Scotch mist, to the tropical down-pour, or in solid hail, the more dreaded because it most frequently occurs at times of year when there is much mischief to be done; or in those feathery flakes of snow which combine with correctness of geometrical principle, such variety of elegant design.

Comparatively few of the skaters who celebrate with

* An elementary account of the chief phenomena of Heat and Light is given in Lecture IV. of the "Science made Easy" Course.

rather egotistic satisfaction the return of grim old-fashioned winters, are aware that the smooth even surface on which they glide along so swiftly, results from a peculiar anomaly in the behaviour of Water with respect to Heat. Its expansion when warmed is altogether less regular than that of other liquids, but a more singular aberration occurs when its temperature is lowered towards the freezing point, that is to say, towards 32 degrees of Fahrenheit's Thermometer, or Zero of the more rational Centigrade scale. For the last few degrees it expands instead of contracting, and a much greater expansion takes place suddenly in passing to a state of Ice. The natural consequence is a bursting of any water-pipes not properly secured against the frost, but on the other hand, an immense benefit accrues as regards open waters. If the density of Water were throughout in proportion to temperature, Ice would be heavier than the liquid in which it forms; instead of floating, it would at once go to the bottom, accumulate there, and not make its appearance at the surface of a pond or stream till the whole depth were one solid mass. Frost under such circumstances would produce disasters among which the mere absence of a smooth skating surface would lose itself in insignificance.

Fifty years ago, Heat was supposed to be an imponderable fluid that could insinuate itself between the particles of a body, and thus push them further apart; or in other words dilate the body without making it heavier; and even now that Heat is considered a mere condition of matter, more or less of an oscillatory or vibratory character, we are still so constantly accustomed to see its absorption coupled with dilatation, and its emission with contraction, that any manifestation in a contrary sense seems paradoxical. Yet in addition to what I have just related, Water in passing from the

solid to the liquid state, whilst it diminishes in bulk to an extent of about one eleventh, actually absorbs in thus shrinking as much Heat as would suffice for raising it from the freezing point to about 80° C. (176° F.) Thus if we take a pound of Ice at Zero Centigrade, in one block filling a tin canister, and burn under it as much gas as would raise the same quantity of ice-cold water 80° C., we shall have a pound of Water not quite filling the canister, and marking on the Thermometer the very same degree as the Ice did.

The fact that so much Heat goes to what in commercial phraseology would be called incidental expenses, has consequences worth noticing. It accounts for the slowness with which the Ice of the Glaciers melts away, even when it has been pushed foward into valleys where a comparatively mild temperature prevails, and for the manner in which Ice-bergs, detached from the great arctic stores, float far down the Atlantic, and become a stumbling-block to navigation. Such is the amount of Heat absorbed by these huge masses, that air and water are cooled down for miles around, and often a fog is occasioned, which increases the danger to mariners by concealing it. On the other hand, we owe to the large amount of Heat required by Ice in order to melt, the facility with which it can be kept from liquefaction in suitable ice-houses, the services rendered even by a small quantity in a well-contrived safe, the length of time for which a cube of Wenham Lake or Norwegian Ice, will without visible diminution form the refreshing decoration of a dinner table, and the smallness of the piece that suffices to cool a glass of Champagne.*

A remarkable effect is produced when a saline compound, or any other substance having a strong

* The manufacture and commercial supply of Ice will be adverted to in the article on the Preservation of Food, Chap. III.

affinity for Water, is mixed with Snow or pounded Ice. Neither is satisfied with this juxtaposition, but merely tantalised ; and the frozen Water in order to pass from a state of solidity which forbids intimate union, to one of liquidity which favors it, borrows Heat right and left in a great hurry. Thus with Common Salt, the temperature is at once brought down to about 23° F. (5° below Zero Centigrade), which is quite sufficient for making those exquisite productions of culinary art known as "Ices." Several articles are more effective than Common Salt. Thus Chloride of Calcium, noted for its avidity for Water, produces when mixed with Snow, as much as 70 or 80 degrees of cold, causing the Fahrenheit Thermometer to fall from 32° to 40° or 50° below its Zero.

In the act of congelation, Water of course gives out Heat in the same proportion as it absorbs it in the act of liquefaction. This accounts for the length of time which it takes to produce Ice an inch thick in a sharp frost. No such notable results are produced in domestic life from this, as from the inverse phenomenon, but it may be proved in a rather striking way by gradually cooling down a glass vessel containing Water deprived of air, and carefully avoiding the least agitation. By a Thermometer fixed with its bulb in the Water you will find that the temperature may be lowered as much as 15 degrees Centigrade below the Freezing Point, without its actually freezing. But give the vessel a gentle shaking, and the whole of the fluid will rapidly crystallize into Ice, whilst a sudden rise in the Thermometer announces the heat evolved.

A phenomenon analogous to that which marks the crystallizing of Water, attends the crystallization of certain saline solutions, and the French savants have it seems, with their usual ingenuity, turned to practical account the peculiar effectiveness with which this property

is manifested by Acetate of Soda. We are told that on the Paris-Marseilles Railway, foot-warmers have been introduced filled with a solution of that Salt, which on passing gradually from the boiling point to below its crystallizing temperature, gives out a prodigious amount of Heat. The appliance can be used for 12 to 15 hours, and then only requires warming again on a stove.

The so-called *Freezing Mixtures* on the contrary, are founded on the property possessed more or less by a great many Salts, and to a high degree by a few of them, of absorbing Heat in the act of dissolving in Water. One of the most efficient, and at the same time one of the cheapest, is Sal Ammoniac (Ammonic Chloride). It is frequently used alone, but a mixture of this Salt with equal parts of Saltpetre, (Potassic Nitrate) is still more effective, lowering the thermometer 40° F. (22° C.).* I am inclined to believe however, that this mode of refrigeration will on the whole be found more useful for cooling down Water and other beverages to an agreeable temperature, than for producing actual Ice.

That in passing from the liquid state to that of Vapour, Water should absorb a large quantity of Heat, seems as natural as it seemed singular in the transition from the solid to the liquid state, for instead of a diminution of bulk, we have an increase of about 1700 per cent., inasmuch as a cubic inch of Water produces at the standard barometrical pressure of 30 inches, about a cubic foot of Steam. This operation absorbs as much Heat as would raise about $5\frac{1}{2}$ times the same quantity of Water from the freezing to the boiling point. If instead of supplying Heat to make Water boil, one stimulates its evapora-

* Interesting details on this subject are given in Ure's Dictionary of Arts, &c., where we read that a mixture of Sulphate of Soda, Nitrate of Ammonia, and dilute Nitric Acid, lowers the Thermometer 64° F.

tion by other means, such as spreading it over a large surface, and submitting it to a current of dry air, the consequent rapid absorption of Heat foı the formation of Vapour is a well-known fact, and one which has often been turned to account. In some tropical countries, a framework of matted grass, or moss, or other suitable material, is kept constantly wetted, and the hot dry wind which passes through it, is cooled down to such a degree that one prefers keeping at a certain distance. For the ordinary purpose of cooling the forehead and temples in the case of headache, we have seen that Ether is used in preference to Water, on account of its much lower boiling point. We have also seen that the cold produced by a current of air mixed with Ether in fine spray, can through instantaneous evaporation, cause a degree of cold capable of entirely benumbing the part on which it is projected ; and of thus serving the purpose of an anæsthetic.

When Water is boiled over a fire, the heat thus treasured up in Steam may be turned to account, just as we utilize, to speak unscientifically, the cold stored up in a lump of Ice. A large quantity of Water may be heated to near the boiling point, by passing into it, a far lesser quantity of Water in the form of Steam, and industrial operations on a large scale are conducted on this principle with excellent results.

When we say Water boils at 212° F., we mean that under the ordinary atmospheric pressure, which is reckoned at 15 lbs. to the square inch, the tendency of Water at the said temperature to pass into vapour is exactly equivalent to that pressure, so that the two counterbalance each other, and no actual ebullition takes place. If the vessel is an open one, any Heat super-added, is absorbed in producing Steam. The rate of that production makes the difference between a quiet simmering,

and a violent ebullition; but provided the Water be pure, the temperature of the steam produced under normal atmospheric pressure, is uniformly 212°, and the Water itself remains stationary at that degree. This is the secret of the Water-bath, which will be alluded to in speaking of culinary operations. If Water be used containing substances in solution, its boiling point rises according to their nature and quantity. Thus with Common Salt, a bath may be obtained marking any degree up to about 228°, and with Chloride of Calcium, a salt noted for its avidity for Water and its unwillingness to part with it, the boiling point may be raised as high as 270°, a fact which we shall find largely utilized in baths for super-heating canistered provisions. On the other hand, if a closed boiler be used, the temperature of both Water and Steam rises, the dissolving power of the former augments in the manner proved by Papin's Digester, and the expansive energy of the latter becomes available as motive power. At 252°, the Steam exercises on the inner surface of the boiler a pressure of 30 lbs. to the square inch, or two atmospheres. One of these is counterbalanced by the atmospheric pressure outside, but there is a motive or explosive power of one atmosphere, that is to say a power capable of driving a column of Water to a height of 33 ft. At 276° the steam pressure is 45 lbs. to the square inch, or three nominal atmospheres, which means two available for useful work, or for mischief, for raising a column of Water 66 ft. high, or for bursting a boiler, if it should be a weak one.

These matters may seem to belong to the province of the Engineer, but the frequent disastrous kitchen boiler explosions proclaim only too emphatically, that they are quite within that of the Hygienist, that they constitute an essential item in the rationale of Domestic Economy,

and that they should be included in the studies of every well-organised School of Cookery.* A certain knowledge concerning the production and power of Steam should indeed be possessed by every one who has charge of a kitchen boiler, and especially if it be one of those contrived to supply hot water to the upper floors, being in connection with the cistern near the top of the house, and having to bear a constant pressure of a column of water say 50 ft. high. It must be borne in mind that the explosion of a boiler constructed to support such a strain is proportionately disastrous. Unless there be a thoroughly efficient safety valve, it is desirable during a sharp frost to secure freedom of the pipes by keeping the apparatus constantly in circulation.

I need scarcely remind you of the low degree of *conductivity* of Water, and of the consequent necessity of warming it by *Convection*, that is to say, by causing a circuit of heated particles. Now Water somewhat impedes the passage of radiated, as well as that of conducted Heat, though this imperviousness is but relative, since more than once a hole has been burnt in a table-cover by the rays of the sun concentrated in passing through a spherical water-bottle. A similar relative opacity to Heat is manifested by Water in the state of Vapour, and in countries where it habitually prevails in the atmosphere, even though not constituting a visible mist, it checks by night the upward radiation from the surface of the Earth. In countries where on the contrary a dry heat prevails by day, the nocturnal radiation in open spaces is so great, as to lower the temperature in a remarkable degree. This often proves detrimental to health through the want of

* "The Daily News" of Jan. 17th, 1881, recorded four domestic boiler accidents. The best safeguards are the use of thin sheet lead safety caps ; or of Cotton's Safety Tap ; or to send up hot water by means of a circulation coil inside of a low-pressure boiler.

proper attention to the rules of Hygiene, but it is much more easily obviated than the oppressive nights resulting in hot countries from a damp atmosphere.

I well remember the description which my Father, who had gone out to India in 1792, gave of a simple and ingenious way in which the free radiation of clear nights, was turned to account for the production of Ice in certain open plains in the neighbourhood of Calcutta. A vast number of small pans of porous earthenware used to be placed on straw, and filled with Water at nightfall, and the effect of a rapid evaporation, and still more rapid radiation of Heat, was such that in the morning each pan contained a cake of Ice, for which the wealthy consumers in Calcutta were content to pay a handsome price.

It is rather peculiar that the invisible Vapour which impedes the passage of rays of Heat, seems to facilitate that of rays of Light; for it is a well-known fact that an increased visibleness of distant objects is a sign of a damp atmosphere. Alpine travellers instead of rejoicing at the distinctness of contours which seems sometimes to bring the mountains forward to meet them, must prepare themselves for the annoyance of rainy weather.

Water in Relation to Light.

Pure liquid Water possesses a degree of transparency of which those who have not travelled, can scarcely have an adequate conception. I can recollect, though more than fifty years have since elapsed, the deceptive limpidity of a mountain rivulet. I knelt down to drink from it in a place where it glided in an unbroken level, and at first plunged my face further than I intended beneath its invisible surface.

The COLOR of Water, so varied in its hues under the

many optical influences which it is the province of the landscape painter to study and to pourtray, becomes decidedly blue whenever its purity, its mass, and its freedom from perturbing causes, allow scope for genuine display.

It is unnecessary to expatiate on the delight with which even the accustomed eye dwells on the azure depths of the lake-purified rivers of the Alps, as for instance the Rhone as it issues from the lake of Geneva. There is in the Bernese Oberland, a sheet of Water which is specially called the "Blue Lake" on account of the intensity of its hue. Some people think it must contain a metallic salt, but great depth sufficiently accounts for its color, combined as it is with a degree of transparency quite extraordinary.

The Waters of the Ocean generally appear greenish for a considerable distance from our coast, owing to the blue rays being mixed with yellow ones, that proceed from suspended impurities, or are thrown up from the bottom long after it has ceased to be directly visible; but it becomes of a deep azure when the depths of the Atlantic are reached. The waters of the Mediterranean, comparatively free from the perturbing influences of tide, have deservedly acquired the title of blue, *par excellence*, as all agree who have seen them in their perfection at the Grotta Scura of the Island of Capri. Even on the small scale to which experiments must be reduced in a physical laboratory, as for instance with a column of Water only 6 feet long, a pale blue tint is perceptible, but such observations abound in causes of error of which it is exceedingly difficult entirely to counteract the influence.

CHEMICAL CONSTITUTION.

More easily determined with mathematical precision are the Chemical Properties of Water, which at the same time lie more obviously in the direction of those physiological and hygienic considerations towards which we are steering our course. I need not remind you that Water results from the combination of two Gases, Hydrogen and Oxygen. This can be very neatly proved by means of two small eprouvettes full of Water, standing inverted in a glass bowl half filled with the fluid. Under each is a little slip or plate of Platinum connected with one of the poles of a small galvanic battery.* As soon as the circuit is established, bubbles of Oxygen begin to show themselves at the positive plate, and bubbles of Hydrogen at the negative plate. They soon rise, and collect in the top of their respective eprouvettes, and it is found that there are two volumes of Hydrogen for one of Oxygen.†

If the quantities thus collected, more or less quickly according to the strength of the Galvanic Battery, are transferred to a single eprouvette suitably prepared for receiving them on a Mercury Bath, deprived of moisture, and exploded by means of an electric spark, Vapour is produced, which immediately condenses into pure Water, without any gaseous residue. Thus, synthetically as well as analytically, we have the most positive proof that Water is composed of 2 parts in *volume* of Hydrogen and 1 of Oxygen, though in *weight*, the matter stands

* A woodcut of this apparatus may be seen in almost every Handbook of Chemistry.

† This is the ordinarily accepted proportion, though in reality the Oxygen being more soluble than the Hydrogen, presents itself in slightly diminished quantity.

very differently. Hydrogen being about $\frac{1}{14}$ of the weight of Air, and Oxygen on the contrary, rather heavier than air, an atom of Oxygen weighs 16 times as much as an atom of Hydrogen, and consequently the one atom of Oxygen in Water, weighs 8 times as much as the 2 atoms of Hydrogen. These data are worth remembering, for they have been made the starting point for the modern system of Chemical Notation.

Water as a Solvent.

The paramount chemical value of Water lies however in the vast power it is constantly exercising as a Dissolving Agent, and a means for bringing into action the respective properties of bodies. In the great majority of crystallized substances, symmetry of form has been arrived at through the plasticity imparted by Water, which in such cases is generally found to be united with the substance in a definite proportion, as Water of Crystallization. The most virulent Acids and most caustic Alkalies are without action on a perfectly dry skin, when they are themselves *anhydrous*, that is to say, perfectly free from Water.*

* It has been explained in the "Introductory Notice" to Lecture V. of the "Science made Easy" series, that in endeavouring to propagate Science among the masses, it is essential to turn to practical advantage any wide-spread popular notions which, crude though they be, possess good working capabilities, and not to upset them till a certain amount of special training has enabled the mind to appreciate and retain more correct technicalities. Thus for instance, the established notion of an Acid is a practical one, and it is more profitable to allow unprofessional beginners to assume that Sulphuric Anhydride is Sulphuric Acid in a dry state, which requires water as a solvent to make its acidity manifest, than to tell them that, as a rule, Acids are Salts, and that liquid Sulphuric

The anomalous tendency manifested by Water in its relations to Heat is extended in some measure to its solvent power, though as a rule that power increases with the increase of temperature, and this is the reason why so many solutions crystallize in cooling. The following are a few examples, normal and abnormal.

Common Alum (Potassium Alum). Water dissolves at 60°, 5½ per cent. ; at 212°, 100 per cent.

Potassium Sulphate. Water dissolves at 32°, 8 per cent. ; at 122°, 17 per cent., and at 212°, 26 per cent.

Sodium Sulphate. Its solubility increases from about 5 per cent. at 32°, to about 55 per cent. at 91°. Thence upwards it diminishes, being about 45 per cent. at the boiling point.

Common Salt (Sodium Chloride). Its solubility is nearly the same at all temperatures, namely, a little under 40 per cent.

Lime (Calcium Oxide). A pint of Water (8750 grains) at 60° dissolves about 11 grains, but at the boiling point only about 7 grains.

Sulphate of Lime (Calcium Sulphate). Its solubility is very small, being only one part in 500 of water, but there is a slight increase with rise of temperature.

Carbonate of Lime (Calcium Carbonate). This is not appreciably soluble in *pure* Water, but Water containing Carbonic Acid Gas, as most natural Waters do, dissolves it freely, as is proved by the geological deposits of Tufa and Travertin, and by the Stalactites and Stalagmites formed in certain caves by the trickling of carbonated waters.

Acid is a Salt produced by the combination of Sulphuric Anhydride with Oxide of Hydrogen, or even, that the metal Hydrogenium forms a binary Salt by combining with the never yet isolated principle, *Sulphion.*

Water in Relation to Food.

It is Water as a *solvent* that renders the contributions of the Earth fit for being sucked in by the rootlets of Plants, and that enables their leaves to absorb the Carbonic Acid of the Atmosphere; nor could without the aid of Water, the products they elaborate reach the places respectively assigned to them.—Equally paramount is the importance of Water in the economy of the human frame. Without it no Food can be swallowed, digested, or assimilated. Nor can it be denied that Water, though looked down upon by many, is the indispensable vehicle of all the lively traffic which is being continually carried on between the organs of our body.

Out of the 154 lbs. reckoned to be the average weight of a full grown man, Water may be computed at 109 lbs., or about 70 per cent.* What is more to the point, it constitutes about 78 per cent. of the mass of the Blood, and if the Corpuscles of the latter be removed, the remaining Serum contains as much as 90 per cent. of Water. With such figures before us, we cannot be surprised at the universal craving of the human system for Water, which, as Johnston rightly says in his "Chemistry of Common Life," "is next in importance to the air we breathe." But the necessity of a constant supply of it becomes still more obvious when we consider the quantity daily eliminated from the system. The loss by perspiration through the skin, may be computed at from 18 to 32 ounces; the quantity breathed out from the lungs, at about 11 ounces, and that drained off through the kidneys, at 50 ounces.

* Considerable diversity prevails on this point in various authoritative works. Thus Johnston gives 75 per cent., Corfield 66, and Huxley 57 per cent.

The supply is fairly apportioned to the demand. Independently of the Liquid Food we imbibe, and which however disguised, mainly consists of Water, a high percentage of the latter is contained in much of our Solid Food. Not only have we seen that Jellies and the like afford proof of this in an extraordinary degree, but the following Food Analyses will show the presence of Water in articles which are commonly reckoned as *dry*. They are taken from the South Kensington Handbook on Food by Professor Church.

Quantities of Water in 100 *lbs. of different kinds of Food.*

Vegetable Food.

	lbs.		lbs.
Fresh Oatmeal	5	Grapes	80
Maize meal	14	Parsnips	81
Wheaten flour	14	Beetroot	82
Barley meal	14	Apples	83
Peas	14	Carrots	89
Haricot beans	14	Cabbages	89
Rice	15	Onions	91
Bread	40	Lettuce	96
Potatoes	75		

Animal Food.

	lbs.		lbs.
Butter	10	Lean of Meat	73
Bacon	22	Fowl	73
Cheese	34	Fish	74
Eggs	72	Milk	86

The following additional percentages of Water are from "Food," by Dr. Albert Bernays. (S.P.C.K.)

Treacle	23	Kohl-rabi	86
Greengages	71	Turnip Tops	90
Peaches	80	Mushrooms	96
Currants	81	Cream	66

It is reckoned that in our country, every adult requires on an average about $3\frac{1}{3}$ lbs. of Water as Liquid Food per day; or to state it in another form, he ought to imbibe about four pounds of Water for every pound of Dry Food consumed. Now though it is clear from the foregoing Tables that our ordinary diet is far from being really dry; yet the deficit of moisture is still considerable, and we cannot better supply it than by selecting Water itself as our beverage. It is important therefore to consider what properties are required to make it at once palatable and wholesome.

DRINKING WATER should have no smell, even when warmed, and no appreciable taste. But this does not mean that we should aspire to have it perfectly pure like our specimen of Distilled Water (×), for we shall find that both gaseous and mineral ingredients are required to make it palatable.

GASES IN WATER.

Water that has been well *aërated* by suitable exposure to the atmosphere, or otherwise, almost always contains in solution, for every hundred cubic inches, from two to five of a gaseous mixture, which though it commonly passes for ordinary air, differs from it in containing

larger proportions of Oxygen and Carbonic Acid. Thus instead of 21 per cent. of Oxygen, it has about 32, and instead of a quantity of Carbonic Acid Gas, under two parts in a thousand, it has as much as 25 to 30. The value of this *Aëration* is shewn by the flatness and insipidity of Water that has been deprived of its Gases by boiling. The Carbonic Acid in particular, imparts an agreeable freshness, which, with increased proportions, becomes that piquant and sparkling effervescence that has won so high a reputation for many of the German springs, and has made the fortune of their artificial rivals. A closer acquaintance with both is reserved for the department of "Refreshing Drinks." We shall also see by and bye that the excess of Oxygen over the atmospheric proportion, or as it is called, the free Oxygen, is not without its use in favoring the disinfecting power of Charcoal- and other similar Filters; but on the other hand it has the drawback of increasing the chances of Lead poisoning, for oxygenized Water dissolves that metal where gasless Water does not.

The only other Gas worth mentioning here, is Sulphuretted Hydrogen, which imparts to sulphurous springs the smell and flavor of rotten eggs, so characteristic of Harrogate. The efficacy of Waters of this description is strictly curative, and they are therefore not within the scope of the present collection. I must however strongly warn you against any Water smelling of Sulphuretted Hydrogen which does not come from a bonâ fide sulphurous spring, for there would be strong reasons to suspect it of having been tainted by decaying refuse.

COMMON INORGANIC IMPURITIES.

Impurities whether *Inorganic* or *Organic*, may be mechanically diffused, or *suspended* in Water, or they may be *dissolved*. SUSPENDED INORGANIC IMPURITIES mostly consist either of Sand, which may be separated by allowing it to settle, or of Clay, or Chalk, or other comminuted minerals, which are got rid of by Filtration.* Instances have occurred of Clay so attenuated as to pass through what seemed impassable. In such cases, or in the absence of a Filter, recourse may be had to Alum and other clarifying agents. (See page 122.)

DISSOLVED INORGANIC IMPURITIES are much more troublesome. It is usual to designate Water for Domestic and Industrial uses, as *soft* or *hard*, according as it has little or much Mineral Matter in solution, and the practice is convenient enough whenever the distinction is a decided one, though the line of demarcation is vague and arbitrary, and it would be almost as difficult to say exactly with how many grains of mineral matter per gallon, Water ceases to be soft, as to state with how many hairs a man's head ceases to be bald. Nevertheless a tolerably satisfactory standard of measurement, known as Clark's scale, is used for determining comparative degress of Hardness of Water. It is based on the fact that good soap forms with *soft* Water a clear solution, and produces under the shaving brush a satisfactory lather, but that it becomes slightly cloudy if the aggregate amount of mineral matter is moderate, and very cloudy, or curdy, when it is excessive. The Water is then pronounced decidedly *hard*, and in order to produce a proper lather, the soap must be used

* For specimens of Filters see Class III. of the Museum, and for their description see the Official Catalogue.

in a quantity proportionate to this hardness. There is however considerable difference in the strength of soaps; and complicated precautions are required for preparing a Standard Soap Solution.* (×)

About one grain of mineral matter per gallon is assumed to constitute one degree of Hardness, two grains two degrees, and so on.† Many more grains must however be reached before a Water is reckoned *hard* in domestic parlance, and the good people of Glasgow may be congratulated on having to all intents and purposes secured a supply of soft Water, by bringing to their homes the waters of Loch Katrine, which according to Church contain less than two grains per gallon.

The following are the amounts of Mineral Matter per gallon, in Water from various sources, according to the "Chemistry of Common Life" by Johnston and Church.

	Grains per Gallon.
River Loka (North Sweden)	0·06
Boston (U.S.) Water-works	1·22
Charles River, Massachusetts	1·67
Bala Lake	1·95
Loch Katrine	1·96
Plymouth Drinking Water	3·00
Thirlmere	3·60
Schuylkill River (Philadelphia)	4·26
Detroit „ (Michigan)	5·72

* See Miller's "Inorganic Chemistry."

† According to Dr. Edward Smith ("Foods," page 279) one pound of Carbonate of Lime, or its equivalent, in 10,000 gallons of Water, is reckoned to constitute one degree of Hardness, and twelve pounds of the best hard soap must be used before a lather will remain. Two pounds of mineral matter in the same quantity constitute two degrees of Hardness, which requires twenty-four pounds of Soap for proper lathering, and so on. This would give for one degree of Hardness, seven-tenths of a grain of Lime Salts per gallon, but Miller gives one grain.

	Grains per Gallon.
Ohio (at Cincinnati)	6·74
Spree (at Berlin)	7·98
Loire (at Orleans)	9·38
Danube (near Vienna)	9·87
Lake of Geneva	10·64
Edinburgh Drinking Water	7 to 14
River Wear (supplying Durham)	15·5
Thames (near London) . . about	21·0
Water supplied to Sunderland	27·00
The Jordan	73·00
London Water Companies.	
New River	19·5
East London	23·5
Kent	29·75

Water supplied to Walton-on-the Naze, of which 182·9 grs. were Common Salt.	228·8

Independently of the saving of Soap effected by the use of soft Water, its superior solvent power may be noticed even in washing one's hands. Its superiority extends to many culinary operations, and it is still more marked in a variety of industrial processes.

For *Drinking*, the case is different. Few persons, unless trained by habit, will pronounce soft Water to be satisfactory to the palate. Even when properly aërated, it has, as compared with good Spring Water, what, if the expression were allowable, one would be inclined to call "an insipid taste." The fact is that a good Drinking Water should occupy a sort of neutral position, being neither decidedly hard, nor absolutely soft. Its qualities are thus summarised in Parkes' "Practical Hygiene."—"Perfect clearness; freedom from odour or taste; coolness; good aëration; and a certain degree of softness."

According to Professor Church, the total Mineral Solids should not amount to 30 grains in the imperial gallon, whilst other authors place the maximum at

20 grains ; and yet these proportions seem moderate if you consider that a gallon contains no less than 70,000 grains. At the Sanitary Congress held at Brussels (1853), the maximum was laid down at 35 grains ; but such rules are of little use, since given quantities of certain salts would be hurtful, and of others harmless, as will be shown further on in comparing Carbonate with Sulphate of Lime.

Let us now by two examples, borrowed from the "Chemistry of Common Life," acquire an idea of the nature and proportions of the prevailing impurities. (See p. 102.)

One of the first things that strike you in these two columns of figures, is the smallness of the proportion of Organic Impurities. This is as it should be, for they are by far the most injurious to health. The Inorganic Impurities, though comparatively conspicuous, are considerably below a total of 30 grains per gallon.

LIME SALTS abound in both instances. In the one Carbonate of Lime or Chalk predominates. In the other Sulphate of Lime or Gypsum. As the latter is by far the most undesirable of the two, it is happy for us that the Limestone and Chalk formations so vastly preponderate over those of Sulphate of Lime or Gypsum.

It has been mentioned, and will be more fully explained presently, that the taking up of CARBONATE OF LIME (×) by Water is facilitated by the presence of an excess of Carbonic Acid. It is a fact less generally known, that the rain which falls on fertile Humus or vegetable mould, finds in its interstices, Air far more charged with Carbonic Acid than the Air of the atmosphere. Some authors say two hundred and fifty times as much. At all events it is obvious that there must be abundance of Carbonic Acid at hand for sharpening, as it were, the Water that trickles down into the Earth, and enabling it to dissolve a portion of any Limestone it may come

IMPURITIES PER GALLON.

	Thames Water.	Kent Water Company.
Carbonate of Lime (Chalk)	10·90 grains	7·02 grains
Sulphate of Lime (Gypsum) . . .	3·26 ,,	11·03 ,,
Nitrate of Lime . .	trace	0·07 ,,
Carbonate of Magnesia	1·17 ,,	3·42 ,,
Chloride of Sodium (Common Salt) .	1·40 ,,	3·50 ,,
Sulphate of Soda .	0·18 ,,	——
Chloride of Potassium .	——	0·44 ,,
Sulphate of Potassa .	0·61 ,,	0·70 ,,
Silica . . .	0·45 ,,	0·76 ,,
Iron, Alumina, and Phosphates . .	0·67 ,,	trace
	18·64	26·94
Organic Matter, with a trace of Ammonia .	3·07	2·61
Totals.	21·71	29·55

across. There are indeed hundreds of places where it comes out again at lower levels so laden with Carbonate of Lime as to form what are more emphatically than correctly named "Petrifying Springs." On reaching the Air, the calcareous solution gives off a part of its gaseous solvent, and throws down the Carbonate of Lime on whatever it touches. Thus are produced incrustations like our specimen (×), or fanciful stalactites (×). Elsewhere the calcareous precipitate accumulates as light porous Tufa (×), or deposited layer after layer, hardens into substantial Travertin (×).

You will readily conceive that for hundreds of such Petrifying Springs, there are more than thousands of other springs and rivulets that hold more limestone in solution than we should care to imbibe into our stomachs, or even to introduce into our tea-pots, for it is well known that Water hard beyond a small amount makes bad Tea. Even Vegetables boiled in it are apt to have Carbonate of Lime deposited in their tissues.

Fortunately means of correction are not wanting as far as Carbonate of Lime is concerned, but to understand their action we must first examine more closely the nature of that Carbonate in the Water to be corrected.

One gallon, or 70,000 grains, of Water will dissolve only two grains of normal Carbonate of Lime, which may therefore be considered as practically insoluble. But a much larger quantity is taken up with the aid of a supplementary portion of Carbonic Acid, which appears to form a soluble Bi-carbonate of Lime.* Sparkling

* Most Books merely state that Carbonate of Lime is soluble in Water containing Carbonic Acid, but the rationale of the softening of hard Water is rendered much more definite by the hypothesis of a soluble Bi-carbonate of Lime, which is distinctly admitted by M.M. Lévy and Motard in their respective Treatises on Hygiene, and appears to have been adopted by Dr. Edward Smith. See his "Foods," page 281.

Waters often contain in addition to this, an excess of Carbonic Acid which is uncombined, and can be removed by the suction of an air pump, or by a gentle heat.—Boiling appears to drive off not only the free Carbonic Acid, but also the supplementary acid of the soluble Bi-carbonate, which being thus reduced to the insoluble Carbonate, occasions a milky appearance, and is thrown down in the form of a precipitate. This largely constitutes the "Fur," that attaches itself to the insides of Kettles and Kitchen Boilers, and in the latter is too often allowed to attain to a considerable thickness, as shewn by our specimens (×). It has been proposed to take advantage of this effect of boiling, to purify waters of which the hardness is produced by Carbonate of Lime, allowing time for the precipitate formed to settle completely, before the water is heated again for use. But this is inconvenient in practice, and I will pass at once to a process decidedly preferable, especially on a large scale.

The method in question, called Clark's process from the name of Dr. T. Clark, the original patentee, and author of the soap test previously mentioned, is founded on the fact that though a gallon of pure Water will, as I said, only take up two grains of normal Carbonate of Lime, it dissolves as much as 100 grains of Lime itself (×). If a small quantity of this solution (×) be added to Water charged with the Bi-carbonate, the Lime will rob the latter of its supplementary Acid, rendering it, and becoming itself insoluble Carbonate.* Thus two lots of the latter will be steadily precipitated together,

* 144 Grains of Bi-carbonate contain 56 grains of Lime and 88 of Carbonic Acid. If other 56 grains of Lime are added, they take to themselves one half of the Acid, namely 44 grains, leaving 100 grains of normal Carbonate, and producing another 100 grains of the same, the two making 200 grains of precipitate.

and the Water will remain comparatively pure, the more so as any slight suspended impurities, and even dissolved organic matters, are likely to be carried down by the precipitate. This process is carried out on a large scale in several localities, including Canterbury, Tring and Caterham. One ounce of Quicklime is added to one thousand gallons of Water for every degree of hardness according to the previously mentioned scale. All the best authorities seem to agree in praising Clark's process for its convenience, efficiency and cheapness. An improvement has been patented under the name of the "Porter-Clark process."*

A Water-softener more used than Lime in the small way for washing, and for boiling vegetables, is Common Soda (×), in which Carbonate of Soda is mixed with the Alkali Soda or hydrated Oxide of Sodium. Bi-carbonate of Soda is however preferred in making Tea, because it has no unpleasant flavor of its own, and serves equally to promote a complete extraction of the aroma.

SULPHATE OF LIME, sometimes called *Selenite*, but more commonly designated as *Gypsum* (×) is the material of which such vast beds are found in the geological basin of the French capital, and which burnt in kilns, produces the well known "Plaster of Paris" (×). That it should there render common well Water exceedingly hard, and next to useless, is not to be wondered at, for a gallon of Water will dissolve as much as 150 grains. Even in England it unfortunately ranks high in quantity among the prevailing earthy impurities, as is indicated by our second example of Water analysis (page 102,), to which we will for a moment recur. You perceive that

* "The only water fit for washing delivered in London during the past year was that of the Colne Valley Company, which was softened by Clark's process before distribution."—Report on Metropolitan Water Supply for 1879 by Professor Frankland, F.R.S., &c.

for the Water of the Thames, Carbonate of Lime is given at nearly 11 grains, and the Sulphate at about $3\frac{1}{4}$, whereas for that supplied to the Metropolis from the deep Kentish wells, Carbonate of Lime is put down at 7 grains, and the Sulphate of Lime at full 11 grains.

I have indeed reason to believe that a large proportion of the hardness of Water generally complained of, is due rather to the Sulphate than to the Carbonate of Lime, and this is the more to be regretted as it has not in its favor the extenuating circumstances which may be pleaded on behalf of the Carbonate. This latter can claim admission to our system on the undeniable plea that it forms an important constituent of our bones. We read the following interesting particulars relating to this subject at page 810 of Michel Lévy's standard work "Traité d'Hygiène," "Boussingault has proved that young animals during growth, derive from the water they drink, the greater part of the Carbonate of Lime necessary for the formation of their bony framework." We read also in Motard's "Traité d'Hygiène Générale," that "Carbonate of Lime is necessary to the nutrition of certain organs, and an excess of it is easily got rid of." I have again Lévy's authority for stating that independently of supplying a constructive material, Lime entering the alimentary canal in the form of soluble bi-carbonate, exercises there an action similar to that of the alkaline bi-carbonates, being decomposed by the digestive acids, with production of Carbonic Acid Gas, which has a stimulative effect on the mucous membranes.

If on the contrary we canvass the demerits of Sulphate of Lime, we find that according to Parkes, Water charged with it, as occurs in a variety of cases * to the extent of 6 to 20 grains, or even more, per gallon, is an unwhole-

* "Calcium Sulphate is one of the most common impurities of Spring water."—Fowne's "Chemistry," xi. ed. p. 363.

some Water, and in many persons produces dyspepsia, and constipation. It is hard, softens little on boiling, and is not good for cooking or washing.

Braun in his great work on the "Curative effects of Baths and Waters" speaks of "Sulphate of Lime as utterly indigestible, and not susceptible of absorption, and as tending to impair the usefulness of Mineral Waters otherwise valuable; instances of the contrary e.g. that of the Water of Weissenberg in the Canton of Bern being quite exceptional."

What greatly aggravates the objectionableness of Sulphate of Lime is the fact that there is not any ready means by which it can be effectually got rid of, as Carbonate of Lime can by Clark's process. It is true that it may be slightly lessened by filtration through Charcoal, and that Common Soda acts on it rather more effectually, especially with boiling, but even when added to the extent of making the Water unpalatable, it does not remove the whole of the Gypsum, as can be seen by allowing the liquid to settle, decanting the clear portion, and adding Chloride of Barium, the well known test for Sulphates.—In short, summing up our comparison of the two Lime Salts in accordance with the division proposed by Dr. Edward Smith, we may consider the Carbonate of Lime as a *temporary* impurity, since it is susceptible of being remedied, and the Sulphate as a *permanent* one, for it can only be effectually removed by the distillation of the Water.

A full analysis of river and spring Water is a task demanding considerable Laboratory practice and resources, and I cannot do better than refer for an account of the modus operandi to the works of Professors Frankland, Wanklyn and Tidy.

Carbonate of Magnesia (×) though far less prevalent than the Salts of Lime is well worth alluding to,

since the analysis of the Kentish Waters shows nearly $3\frac{1}{2}$ grains per gallon, and in the localities where Magnesian Limestone prevails, much more may be expected. It need not however raise apprehension, as it is easily dissolved by the acids of the alimentary canal, which convert it into salts of a laxative tendency.

CHLORIDE OF SODIUM, or Common Salt, (×) would still less require notice, were it not that its presence raises a rather delicate question concerning its origin. In the neighbourhood of the Sea,* or where a marine origin is obvious, its appearance is perfectly justified; but when it cannot make good a legitimate *raison d'être*, a suspicion arises, especially if it should be in any notable quantity, that it may have been associated with the refuse of human habitations, and careful investigation should determine whether it may not still have in its company, some noxious organic impurities.†

Iron and Lead.

IRON and LEAD are the only familiar Metals of anything like common occurrence in Drinking Water, but the difference between them is remarkable. IRON is so prompt to announce its presence by an unpalatable styptic taste, and by the red color it imparts to the vessels

* It has been shown that the Water supplied to Walton-on-the-Naze on the Essex Coast, contains as much as 183 grains of Common Salt per Gallon.

† Dr. Tidy found as much as 25 grains per gallon in City Pump Water, where no legitimate cause for its presence could be assigned. —Very small quantities of Chloride of Sodium may be detected by Nitrate of Silver, for the mode of using which see "Food" by Prof. Church, according to whom any quantity above $1\frac{1}{2}$ grains per gallon may be viewed with suspicion.

in which the water containing it is allowed to stand, even though it may not be in sufficient quantity to give the liquid a perceptible tinge, that there is very little danger of imbibing it unawares, beyond those minute proportions in which it is for most temperaments rather a wholesome tonic than otherwise. Water that is decidedly ferruginous, or to use the expression adopted in medical language, *chalybeate*, should be used with a certain amount of caution, as its astringent quality is apt to cause with many persons constipation, and a tendency to headache.

The presence of more or less Iron in Spring Water, is a thing to be expected in localities where its oxides (×) redden in a notable degree the gravel beds or sandstone (×) formations. It is sometimes also occasioned by the rust which is allowed to collect on the inside of water pipes (×) before they are used, and of which the first customers have the full benefit.

LEAD is as insidious and as dangerous as Iron is plainly manifest and comparatively innocuous. Its best-known soluble salts are noted for a fallacious sweetness, which, though coupled with astringency, is rather agreeable to the palate; so much so that Acetate of Lead, known as *Sugar of Lead*, used by an iniquitous fraud, to be employed in the adulteration of certain wines. But the fact is that in potable Water, Lead is injurious in quantities not perceptible to the taste, and not even easily detected by chemical tests; for in common with some other poisons, it has the property of accumulating in the system.

It is this property which renders the use of White-lead so injurious to house painters, producing after a length of time the notorious painters' colic, paralysis, and other distressing complaints. These effects have long been known, whereas those of Drinking Water containing Lead

appear to have been studied more recently, and especially since the sad case which occurred in the household of Louis Philippe, the ex-King of France, at Claremont. The amount of Lead in the Water which there had such fatal consequences, was found to be seven-tenths of a grain per gallon, but a much smaller proportion suffices to create danger. Some authors attribute cases of bad paralysis to the presence of one-hundredth of a grain per gallon, though it seems sufficient to follow Parkes, who states that any quantity over one-twentieth of a grain per gallon, or indeed the chemical detection of the merest trace, should be considered dangerous.

How then are we to account for the vast development of the use of Lead for supplying pipes, cisterns and the like, and the comparative immunity from Lead poisoning enjoyed in the Metropolis? The explanation of this welcome paradox lies in the protective power of the Lime Salts, which generally occur in a moderate and inoffensive amount in the Drinking Water supplied by springs and rivers. They tend at once to prevent any Oxide of Lead, formed by the action of the Oxygen which the Water contains, from being readily dissolved, and moreover they soon produce a film or thin coating which, under favourable conditions, impedes further action.*

An equal immunity is possessed by Distilled Water before it has been in contact with the Air. But the case is very different with Rain Water, which in its descent from the clouds has amply provided itself with Oxygen. An oxide (×) is promptly formed on the surface of any lead gutters, pipes, and cisterns prepared for its reception, and as it is perfectly soft, containing only about

* Sulphate of Lime is included by an eminent author as a protective, with the Carbonate and Phosphate. Yet we are told that the contact of Plaster of Paris with Lead should be avoided, as it occasions corrosion in the presence of moisture.

two grains of earthy salts per gallon, that oxide is readily dissolved.

The presence of Zinc tends materially to promote the oxidizing and dissolving of Lead, and Zinc pipes of impure quality, which often contain a small quantity of that metal, without its presence being suspected, are doubly dangerous.

There are also several substances of which the presence in Water tends to promote its action on Lead, such as Chlorides, Nitrates, Nitrites, Ammonia, and especially Organic Matter in decomposition.* Free Carbonic Acid in soft Water converts the Oxide of Lead which may be produced into a Carbonate of Lead, (×) which though insoluble, forms apparently on account of its crystalline or fibrous consistency, an imperfect preventive to the further oxidation of the Lead which it covers. It is moreover soluble in an excess of Carbonic Acid.

Unfortunately there is not any innocuous chemical agent by means of which Lead contained in Drinking Water can be disposed of, as Carbonate of Lime is got rid of in Clark's process. To a certain extent, Filtration may render service, and some of the recently devised Filters, such as those with Silicated Carbon, and Spongy Iron, are advertised as capable of wholly removing this dangerous metal ; but the best safeguard is to keep wide awake as to any causes of mischief that may occur, and to have a test for Lead ready at hand. The most convenient is Sulphide of Ammonium (×), which causes a black precipitate, not cleared up by Hydrochloric Acid, even in a very dilute solution of any Lead compound (×). Sulphuretted Hydrogen in its gaseous state, or dissolved in Water, is perhaps still more efficacious, but the Gas is

* It is said that Nitric Acid is found in the atmosphere after a thunderstorm. The solvent effect of Water containing it on Lead surfaces may be easily conceived.

troublesome to prepare, and the Solution soon loses its value. A bad smell is avoided, and a pretty colour obtained, by using a solution of Chromate of Potassa.

Organic Impurities.

The searching investigations of the causes of epidemic diseases which have figured so conspicuously in modern medical research, have established beyond question the vast amount of mischief attributable to the use of Water containing Organic Impurities. I cannot do better than refer to Dr. Parkes' "Practical Hygiene" for a chronological review of the occurrences which have thrown light on this question within the last 120 years, leaving no doubt as to the power possessed by polluted Water for engendering Diarrhœa, Dysentery, Typhoid Fever, Cholera, Yellow Fever, and other fatal diseases.*

Dr. Lankester has the following in his Report to the Vestry of St. James, Westminster (1857). "The deleterious effect produced by organic matters is well illustrated by the history of the Lambeth and Vauxhall Water Companies, which supplied water to the same district on the south side of the Thames, during the

* One or two of the cases mentioned by Dr. Parkes, strongly favor the idea that Water foul with the worst pollutions, does not engender a Zymotic disease without the presence of special germs derived from an individual suffering from the particular malady; but it is obvious that at some time or other of the Earth's history, when a Zymotic disease made its first appearance, its germs must have had an origin without a progenitor, and what prevents that which has happened once from happening again under similar circumstances? At all events the range of evils that may arise from drinking polluted Water is so considerable, that I should advise no one to run the risk of drinking it because he has not heard of any recent case of Typhoid Fever or Cholera.

cholera epidemics of 1848 and 1854. In the former year both Companies derived their supply of Water from the Thames at Battersea, and both the districts supplied by these Companies suffered equally from cholera. But in the year 1854 the Lambeth Company obtained its supply of Water from Thames Ditton, beyond the influence of the tide. In consequence of this change, less than one-third of the number of deaths occurred in the second outbreak of the cholera (1854) in the houses where the purer water was drunk, as compared with those supplied by the other Company."

I borrow from Dr. Parkes' "Practical Hygiene" an incident which appears to have very much attracted the notice of Hygienists, and seems to afford incontestable proof of the deleterious action of impure water: Three ships with troops were started from Algeria to France at the same time, and under precisely similar circumstances, with this exception, that one was supplied with Water from low marshy land where ague was prevalent, whilst the others had taken Water from a much more elevated locality where the disease was unknown; on the first ship many of the soldiers were taken with intermittent fever, and some 12 or 14 died, in the other vessels not a single case of illness occurred.

Tests.

The following are among the most convenient and reliable of the Tests devised for ascertaining the presence of Organic Impurities.

The application of Heat often develops in impure Water a nauseous smell, not perceptible when cold.

If a certain quantity, say a pint, be evaporated to dryness in a glass or porcelain dish, the residue of Earthy

Salts, will if tainted with Organic Impurities, assume, instead of a pure white (×), a more or less yellowish, greenish, grey or brown appearance (×).—If these impurities should be of animal origin, they will probably give off on heating, an odour resembling that of burnt feathers.

The metal Manganese forms with progressive doses of Oxygen certain oxides, of which the highest is well known for the facility with which it parts with a portion of the gas. But besides these, it forms with still higher proportions of Oxygen, two Acids known as Manganic and Permanganic ; the former containing 48 grains, and the latter 56 grains of Oxygen, for every 55 grains of the metal. Accordingly the salts formed by these acids with the alkalies, and especially the Permanganates, are always ready to supply Oxygen to any Organic Matter with which they may come in contact, and thus to oxidise and destroy it. This is the secret of Condy's celebrated fluids (×), which deservedly occupy a distinguished position, both as Disinfectants, and as Tests for Organic Impurities. The weaker one is known as the Green Fluid, though its color is too dark to be easily recognised. It is a solution of the Manganate of Soda, and is preferred for purposes of disinfection where large quantities are required. The purple, of double the price, is a solution of the Permanganate * (×). Its disinfecting power is in certain cases truly marvellous, and is an immense boon to medical men engaged in post-mortem examinations, and the like.

As a Test, it is as convenient as it is effective.† Into a tall glass full of the Water to be tested, is poured a

* It is with this salt that is also prepared the so-called Ozonized Water, so efficacious as a mouth-wash.

† It is well however to bear in mind that the Manganates do not attack all kinds of Organic Products, and that on the other hand, salts of Iron produce with them deceptive precipitates.

quantity of the fluid just sufficient to impart to the whole a uniform pink color. If the Water be highly impregnated with Organic Matter, that color will rapidly change to a dirty brick red, and after a time, a dingy sediment will be produced, the Water becoming nearly colorless (×). If on the contrary the Water be almost pure, many days may elapse before the beautiful pink color fades away. Between these two extremes, increasing intervals of time mark so many degrees of a decreasing scale of impurity. To this criterion of time, a criterion of quantity may be added, by noting the proportion of brownish sediment produced by different samples of water in a number of elongated test-tubes arranged in a rack.

In these experiments, and those before mentioned of evaporating and heating the residue, only a general conclusion as to absence or presence and aggregate amount of Organic Matter is arrived at, with scarcely any indication of its special character. Yet there is wide scope for diversity in this respect, as may be seen by the following brief particulars.

Varieties of Organic Impurity.

In many samples of spring and river Water, and still more in that which has been stagnant in ponds, or stored in uncleansed cisterns, the microscope reveals living organisms, the sight of which cannot fail to create a lasting impression, and in some cases a very salutary disgust. Some of these minute creatures are remarkably tenacious of life. According to Burdon Sanderson, quoted in Parkes' "Hygiene," the extinction of vitality in certain Bacteria is not assured under 230°. But more formidable than even such a temperature to animal life, is probably the digestive power of the gastric juice, which

without distinction of the varied material composing these microscopic beings, would probably soon make jelly of them all. Here then does not lie the real danger of the Organic Impurities of Water, though every one will prefer that its population should be left behind in a Filter.

Unfortunately there are organic germs too minute to be arrested by the most compact sand-bed, or the most compressed charcoal, and for which even spongy iron might be an insufficient obstacle. There is strong reason to suspect that millions of spores, ovules, and other reproductive or metamorphic forms of Vegetable or Animal Life fraught with disease and death, but too small for detection even by the most powerful microscope, and of which science has not yet been able to determine the exact nature, or even to distinguish the vegetable or animal origin, float about in polluted Water, ready whenever they can gain access to pre-disposed systems, to grow and multiply with contagious virulence. They are equally wafted about in the atmosphere, and abound in dust like that of the London streets, but they seem less apt to thrive in the tissue of the lungs, than when introduced through the alimentary canal, of which the digestive action appears in many cases to be powerless for their destruction.

Another condition of Organic Matter in Water consists of detritus, or miscellaneous fragmentary particles, lifeless and shapeless, but still *suspended*, not dissolved. This includes shreds of vegetable fibre, and of animal substances equally insoluble, e.g. the Keratin of hair, feathers, &c. With these may perhaps be associated a few extra tough specimens of the Albuminoids, but they are mostly prone to putrid decomposition, and they then seem to acquire the infectious activity of Ferments, engendering change in whatever they touch.

Dissolved Organic Impurities may, like the preceding *suspended* ones, be conveniently sorted into three groups. There are coloring matters like those which Water takes up in traversing a peaty country (×), and which though their taste may be unpalatable are not proportionately unwholesome.*—A second group of Soluble Organic Matters comprises those of which the presence is decidedly disagreeable, though the unpleasantness may vary in kind and degree. As examples of widely differing character, I may mention on the one hand certain Volatile Oils of nauseous taste and odour, called Empyreumatic Oils, and which are commonly produced by the destructive distillation of vegetable and animal substances; and on the other hand Urea, sufficiently condemned by the mere fact that it is the special refuse product of the animal system.—The third and last group consists of Organic Salts, not susceptible of putrid decomposition, including such vegetable ones as Tartrate and Oxalate of Potassa, and such animal ones as Phosphate and Carbonate of Ammonia. This last mentioned being volatile, can be got rid of by aëration, if it should be in sufficient quantity to occasion an unpleasant odour or flavor.

* According to Dr. Tidy, the particles of Peat, though too minute to impair the clearness of the Water, may be considered rather as suspended than dissolved. In proof of this he adduces the circumstance that a precipitate obtained by the admixture of turbid Water, serves to remove the coloration, and gives the example of the peaty water of the Shannon thus purified by the turbid Water of the Mulcaire. (See Journal of the Chemical Society for May, 1880, page 300.)—The comparative innocuousness of Peaty water is attested by Ekin in his "Potable Water," page 15.

FILTRATION.

Setting aside as comparatively unimportant the Saline Impurities just described, we find that the rest are mainly disposed of by FILTRATION, which may add *Chemical* to *Mechanical* Action.

MECHANICAL FILTRATION which is a mere straining of the Water to keep back *suspended* impurities, is mainly performed by causing the liquid to pass through a bed of Sand (×), which is generally supported by layers of clean gravel of successive degrees of coarseness, the finest being always next to the Sand. In small Filters, organic materials are occasionally used, such as Sponge, Flannel or Wool, and the latter is sometimes tanned, but sufficient account is not always taken of the tendency to deterioration to which Organic Matters in a state of continual moistness are well known to be prone, and cases have not unfrequently occurred in which the Filter has *added* to the impurities of the Water which it was expected to purify.

Various examples of the devices of which we are now only discussing the general principle will be seen duly arranged in Class III. of the Museum, whilst their description will be found in the Official Catalogue. You will find that a slab of firm but porous Sandstone, is frequently used in House Filters, in lieu of a bed of Sand. I have also seen a bottle of porous earthenware that would fill itself by degrees with pure liquid abstracted from a turbid pailful in which it was placed.

MECHANICAL AND CHEMICAL FILTRATION, unites with the principle of the strainer or sieve, a certain amount of oxidising action by means of which Organic

Matters in solution in the Water, or too minute to be arrested by mere straining, are actually consumed and destroyed. Of late years, certain forms of Iron, especially the Magnetic Oxide, and the so-called Spongy Iron (×), have been introduced for this purpose, on account of the facility with which they absorb Oxygen, and give it out again; but the substance still popularly recognised as the purifier, *par excellence*, is CARBON or Charcoal (×).

The attention of philosophers has long been directed to the peculiar capability of Charcoal for absorbing large quantities of various Gases. The experiments of the eminent Genevese savant, Théodore de Saussure, threw much light on this property, and Thénard in his "Traité de Chimie" (Vol. I. page 162) gives interesting tables of the respective quantities absorbed by this and other porous substances. Nor were the practical advantages derivable from Charcoal as a decoloriser, deodoriser and disinfectant, overlooked. I well remember seeing, as a boy, at Paris in 1816, a manufactory of Charcoal Filters, appliances which rapidly gained popular favor. Yet up to the present time numberless as have been the enquiries into the rationale of their action, this point is still far from having been brought to a definite conclusion. It is evident that something more occurs than a mere separation from the Water of unaltered Organic Impurities; for:—1stly the accumulation of these in Charcoal is not at all in proportion to the work done;* and 2ndly in the Water issuing from the Filter, certain Nitrites and Nitrates are found which did not previously exist in it, and which must be considered as products of the oxida-

* A statement by Mr. Chapman recorded in the proceedings of the Institution of Civil Engineers for 1867, to the effect that he had recovered from a Carbon Filter the whole of the Organic Matter abstracted, appears to be considered as referring to an exceptional case, testimony of an opposite character being overwhelming.

tion of nitrogenous matter.* Accordingly it is supposed by many, that free Oxygen dissolved in the Water, is abstracted by the Charcoal, stored in its pores, and there employed for consuming the impurities in question. It is true that the latter have been travelling with the Oxygen dissolved in intimate association, and one does not see why the combustion might not as well have happened by the way. But it must be borne in mind that Chemistry presents a number of cases of so-called Catalysis, in which the action of two bodies on each other is induced, or promoted, by the presence of a third body, which itself does not undergo any perceptible change. Perhaps it would be as well to say that the Charcoal, without abstracting from the Water either Oxygen or impurities, simply urges them to a conflict which substitutes Combustion for Putrid Fermentation, and disorganises every living organism. The part of second to the fight is certainly exercised by the Charcoal, not only with complete success, but with what one might almost be tempted to call intelligent discrimination ; for if Albumen in a fresh and wholesome state, is present in the Water, it is allowed to pass, whereas Albumen in a state of incipient decomposition, precisely the state in which it is apt to exercise the infectious power of a ferment, is at once arrested, and handed over to the caustic action of the Oxygen.

Much more frequently discussed however than the *rationale* of Charcoal Filters, is the *extent* of their usefulness, and on this score the apparent antagonism of authoritative opinions and authentic facts, is not a little

* The formation of Nitrites is positively affirmed at p. 34 of Parkes' "Practical Hygiene," and the statement at p. 35, to the effect that Carbon Filters diminish the amount of Nitrites, shows that Carbon possesses an absorbing as well as a catalytic power.

perplexing. In an experiment conducted by Mr. Byrne, the power of a Filter containing nearly 5 lbs. of Charcoal was exhausted in a few hours, by the abstraction from Water of 43 grains of organic matter. On the other hand, Dr. Letheby and Professor Frankland have brought forward facts to show that animal Charcoal retains for a long time a power of inducing a chemical change in organic matter. The former obtained some Charcoal which had been used for two years, and through which nearly 300,000 gallons of Water had passed, and which still retained the power of depriving Water of color and of organic matter. A careful investigation shewed that the latter had not accumulated, for Nitrites in the filtered liquid clearly demonstrated that it had been oxidised.— Nevertheless according to Parkes, it seems to result from the sum total of the experiments on Charcoal Filters, that the limits of purification are sooner reached than commonly supposed, if the organic matter be in large amount, so that a more frequent cleansing is required. When however the amount is small (not exceeding 1 or 2 grains per gallon) the action is very permanent.

It is right to mention that Animal Charcoal, obtained by heating bones in close vessels, and dissolving away the salts by means of Hydrochloric Acid, appears to be specially esteemed for filtering purposes. Charcoal prepared from Peat or from Wood is decidedly inferior, and Dr. Frankland seems indeed to consider the latter as useless, though Seaweed Charcoal is said to be efficacious.

The common practice of steeping Toast in Water may besides the palatable flavor imparted, have a certain amount of disinfecting action through its carbonised surface.

You will find in reviewing the Filters, that in some the principle of straining through Sand is united with that of purifying by means of an oxidising agent, such

as Charcoal or Iron; the straining and purifying substances being used, either successively, or mixed as in the Silicated Carbon Filter. You will also see that in the best Filters, provision is made for a very necessary occasional cleansing. Sometimes Water is driven through the Filter the reverse way, for the more effective removal of accumulated impurities; but more frequently copious sluicing is resorted to. Rinsing with clean Rain Water turns to account its superior solvent quality, as compared with Water charged with earthy salts.

Aëration by driving a blast through the Filter, adds oxidation where mere washing would not suffice. But the point most worth considering is the revival of the clogged charcoal of Carbon Filters. The most effective means, where available, is its calcination with proper precautions against combustion. More frequently the plan is adopted of washing with Condy's Permanganic Fluid, diluted with distilled Water or clean Rain Water, and sharpened with a little Sulphuric Acid. An ablution with weak Hydrochloric Acid removes any deposited Oxide of Manganese and Carbonate of Lime, and the operation terminates with a good rinsing, for which distilled, or clean Rain Water should again be preferred.

Clarification.

Where a Carbon- or Spongy-iron Filter is not to be had, Water charged with Organic Matter even in a state of solution, may be purified by the careful employment of Condy's Purple Fluid, but this plan requires the supervision of a practised Chemist. As regards the clarifying of Water rendered slightly turbid by suspended impurities, organic or inorganic, provided there be Carbonate of Lime in solution, ALUM (×) well deserves the

popularity it has maintained for ages. Sulphate of Lime is formed, and a bulky Hydrate of Alumina entangles the floating particles in sinking to the bottom.

Ordinary Clay which is a gross and impure Silicate of Alumina, preserves in some measure the foregoing property of its parent Earth, and the example given by Dr. Tidy of the effect of the turbid Water of the Mulcaire on the peat-stained Water of the Shannon, suggests the possibility of its use in certain cases where the required time for its slow, but clean-sweeping subsidence can be allowed.

The action of the nuts of *Strychnos potatorum* (×), of which Indian travellers often carry a supply, and of other vegetable articles known to produce a clarifying precipitate, appears to be mainly owing to the combination of the Tannic Acid which they contain, with certain gelatinous or albuminous materials present in the Water to be purified.

Clark's process, of which the main aim is the removal of Carbonate of Lime, but which acts also to a certain extent on Organic Impurities even in solution, has already been described.

Let us now proceed to a cursory review of the chief sources from which a supply of Drinking Water is usually obtained. This will afford us a convenient opportunity for ascertaining the impurities most commonly prevailing in each.

SOURCES OF DRINKING WATER.

Distilled Water for Ship use.

The vast development of Steam Navigation, has naturally given a great impetus to the conversion of Salt Water into a wholesome Drinking Water by Distillation, and has led to considerable improvements in the process. Steam from Salt Water leaves of course the salts behind; nor is there any difficulty in condensing it. This has been even done on an emergency by simply collecting it with clean woollen garments, and squeezing out the fluid with which they became saturated. But *distilled* Water has like the *boiled* Water to which I alluded, a disagreeable flatness, owing to the absence of gases, and it was found that the ordinary appliances by means of which it was aërated, did not satisfactorily overcome this objection. Dr. Normandy, who made this matter the subject of an intelligent investigation, drew attention to the fact that the gases commonly contained in Water, include, besides free Carbonic Acid, a certain amount of free Oxygen; that is to say of Oxygen beyond the normal standard of admixture with Nitrogen which prevails in the air we breathe. He accordingly devised an ingenious apparatus in which gases abstracted from the Salt Water used for cooling the Steam in the Condenser, are supplied to the pure Water from the Still. It is essential that this operation should be performed before the Water comes in contact with any less desirable gases, or noxious emanations, for in its gasless state it absorbs everything of the kind with remarkable avidity.—A peculiar advantage of Dr. Normandy's mode of aëration manifests itself in the next department of his process, in which the Water is made to pass through a Charcoal Filter. The Carbon

turns to the best account the free Oxygen for entirely consuming certain empyreumatic oils produced in the Still by the decomposition of the organic matter in the Sea-water, thus doing away with the mawkish odor and taste which were at one time considered as almost inseparable from distilled Ocean Water. A Refrigerator, or cooling apparatus, gives a finishing touch, and the limpid, sparkling fluid turned out (×) is altogether so satisfactory, that Normandy's Patent Apparatus is adopted in H. M. Navy, with the influential recommendation of the Trinity Board. It is true that after long use, complaints of unwholėsomeness are sometimes heard, which may probably be ascribed to the absence of the Earthy Salts prevailing in Spring and River Water, and which, as before explained, are, within a limited proportion, a useful constructive material. The question naturally presents itself whether this deficiency might not be advantageously supplied by Citrate of Lime.

It is scarcely probable that any one would incur the risk of placing Lead in contact with such a solvent as Distilled Water is after it has been aërated, but it may be well to mention the danger that might result from its action on the solder which is often used for uniting the parts of an apparatus.

Rain- Ice- and Snow-Water.

RAIN-WATER (×) being used for drinking, as well as for cooking in some countries, and being resorted to with advantage where Springs and Streams are highly charged with Lime Salts, or are otherwise impure, it is useful to know its strong and its weak points.*—Its aëration is good in quality as well as in quantity, for the gaseous

* New Orleans is mentioned as one of the places where necessity induces the use of Rain-water.

mixture which the Rain-drops take from the atmosphere as they fall, contains 32 per cent. of Oxygen, and $2\frac{1}{2}$ to 3 per cent. of Carbonic Acid, whereas you are aware that ordinary Air contains only 21 per cent. of Oxygen, and only from 3 to 6 per ten thousand of Carbonic Acid. In localities where much smoke prevails, or fumes worse than smoke arise from chemical factories, a slight consequent result is perceptible, and apart from this, one can generally detect traces of Ammonia or Ammoniacal Salts derived from organic decomposition; but these are in quantities too minute to be taken into account, any more than the occasional presence of certain peculiar Spores,* or the rare and perhaps exaggerated phenomena of blood-stained drops, of showers of fishes, and the like, to say nothing of the ordinary vegetable and animal germs for which the atmosphere is supposed to be the universal receptacle. Taken as it generally reaches the earth, Rain Water may be considered as very free from Organic Impurities, but in collecting and storing it, we must be on our guard in using the Water of showers that fall after periods of drought, on roofs more or less tainted with smoke, covered with dust, subject to accumulations of leaves or bloom from neighbouring trees, or frequented by the feathered tribes. The same caution applies to the gutters, pipes, and water-butts or cisterns. I am now merely alluding to cleanliness. As for the actual danger which may arise from the prevailing use of Lead in many of these appliances, it is well to remember that Rain-water owing to the almost total absence of earthy salts, and to the presence of free Oxygen, is in a condition peculiarly favorable to the formation and solution of the poisonous oxide of that metal.

It is obvious that the absence of Carbonate of Lime, which is supposed to be detrimental to health in a pro-

* Those of *Protococcus pluvialis.*

longed use of Distilled Water, is not unlikely to be injurious to the system in the case of Rain Water, unless watched and counteracted.—For washing, Rain Water is first rate, and were it only for this purpose, the arrangements for collecting it should not be neglected, including rejection of the first roof-washings after dry weather.—For cooking, it is also excellent. I may however remark that according to some authors its deficiency of earthy salts is rather injurious than beneficial in producing a delicately flavored cup of Tea, inasmuch as it extracts too rapidly the bitter principle, in addition to the aromatic one which less solvent Water tends to isolate.

ICE-WATER, that is to say, melted Ice, is soft but flat, because in congealing, Water parts with its gases as well as with its mineral salts. It is however apparently a fallacy to believe that it equally gets rid of all organic impurities. An American naturalist has been microscopically examining fragments of the clearest Ice, taken from various canals and ponds. The melted Water was found to contain vegetable tissue and confervoid growth, and after a time monads made their appearance.

MELTED SNOW is almost identical with Rain Water, and Snow, where it abounds, is so easily collected in a state of purity, that one wonders what ideas of cleanliness can prevail among the Russian peasantry, who are said to have brought on themselves a visitation of Cholera in the winter of 1832, through their use of Water from contaminated Snow.

Wells and Pumps.

Where layers of gravel and other porous alluvial deposits lie on a broad bed of impervious clay, the Water accumulates on the latter to a level which rises and falls

with tolerable regularity according to wet and dry seasons, as may be ascertained by means of the many WELLS which in such favourable localities are likely to be dug. I have found that the Water of Wells thus grouped within the space of an acre or two of apparently level ground, may vary much more as to the respective amounts of Carbonate and Sulphate of Lime, and as to presence or absence of Iron, than could have been expected. Yet they seem to agree in a general steady flow of percolation in the direction of a slight dip in the clay bed, a fact indicated by their relative amounts of organic impurities, which depends less on the propinquity, than on the direction of the neighbouring cesspools. This is a circumstance worthy of attention, as showing that, for instance, it may make a great difference whether the Well that supplies a Farm Yard be higher up or lower down in the general flow of percolation.

Unfortunately the almost utter want of sound notions that has long characterised the education of the great bulk of the People, has not only barred the way to considerations like these, but has produced, especially in populous towns, an almost incredible amount of obtuse callousness in continuing to use Wells whose surroundings have become sodden with the contaminations of centuries.

Dr. C. M. Tidy in a private communication dated 1867, animadverted in strong terms on the condition of the London Pumps, naming but two exceptions, those of the Glovers' Hall Court, and of the Guildhall Buildings, which derive their water from deeper strata. He quite agreed with Dr. Lankester in deploring the dangerous fascination exercised on an ignorant public by waters which derive an inviting flavour, and a peculiar sparkling freshness, from their abundant Carbonic Acid and saline ingredients. These are them-

selves derived from the oxidation of impure organic matter, and serve to conceal the presence of other organic impurities not yet oxidised, and therefore in the highly dangerous stage of actual fermentation and decay. Contagion lurks in the insidious draught which thus lures its victims to destruction.* Dr. Letheby, Mr. Simon and many other high authorities ranging up to the present time, concur with those above named in pronouncing a condemnation of the London Pumps, and expressing a desire for their abolition. It is in reading reports like theirs that one is brought to a thankful appreciation of the great amount of good effected by the Drinking Fountains' Association.

Far greater benefit to the poor of the Metropolis will accrue from the gradual adoption by the Water Companies of the *Constant Supply* System, for the *Intermittent* System hitherto prevalent is mainly to blame for the existence of the thousands of rotten water-butts, open tanks and filthy cisterns, which have hitherto falsified the reckonings of the official analysts. However, even under the improved system, negligence, dirt and disease will still be rife till a population, hitherto ignorant of the revelations of Science, has been educated to comprehend the precepts of Hygiene, and to adopt the well-devised safeguards of Cleanliness and Health, of which it is the purpose of the Parkes Museum to spread the knowledge and the appreciation.

* See Dr. Lankester's Report to the Vestry of St. James' Westminster, 1857.

Springs.

Though SPRINGS are much more associated with ideas of purity than Wells, they are not always to be trusted. In a country with gentle slopes, and hills neither lofty nor precipitous, they are often the outcome of a comparatively shallow drainage much influenced by surface conditions, which where either forests or minor forms of wild vegetation prevail, produce Carbonaceous impurities, and where cultivation manures the soil, render manifest in various ways the more dangerous presence of Nitrogenous matter. In such regions the remark above made in reference to Wells, applies in some measure to Springs ; namely, that one must take into account the direction as well as the propinquity of causes of contamination. For instance a Spring of the purest Water may issue without a shadow of suspicion from a rock within the upper precincts of a Cemetery, being evidently supplied by a hill outside; whereas if the Cemetery occupied the slope above, or even the broad summit of that hill, the case would be suspicious.

Springs of the true original type are those which issue sparkling from the mountain side, free from all taint of civilization, and well aërated, though often laden with Lime Salts dissolved in trickling down through the crevices of rocky formations, or in creeping along their strata. It has just been mentioned that the gaseous mixture with which Rain-water is amply provided, contains about 32 per cent. of Oxygen, or about 11 per cent. more than Atmospheric Air, and about 2½ to 3 per cent. of Carbonic Acid, instead of 3 to 6 parts in 10,000, which is the usual proportion in our Atmosphere. It has also been mentioned elsewhere, that a further quantity of Carbonic Acid is imbibed in the interstices of the ground,

especially where the latter consists of fertile humus. So you see that Rain-water is well supplied with the means for dissolving any suitable materials it may meet with in descending through a portion of the earth's upper crust. This sufficiently accounts for any ordinary amounts of Carbonate of Lime held in solution in mountain Springs, and Geologists have no difficulty in explaining the presence of any further quantity of Carbonic Acid which may be necessary to account for the superabundance of Lime Carbonate in those which deposit it so freely on reaching the open air. We must however conceive the evolution of abundant Carbonic Acid under very considerable condensing power, coupled with the comparative absence of Limestone-strata, in order to understand the production of those highly effervescent Waters free from tufaceous deposit, for which some of the Brunnen by the Rhine have become so famous.—I reserve a few words on Hot Springs for the subject of Artesian Wells.

Sometimes the subterranean union of many baby springs produces a stream that issues from the earth with adult dimensions and energy. Not the least interesting among the examples of this phenomenon is the Well of St. Winifred, at Holywell on the borders of North Wales, which throws up, it is said, 100 tons of Water per minute, forming a stream that makes itself at once useful in turning a large mill. Another, four times as copious, is the celebrated fountain of Vaucluse, a favorite theme of the poet Petrarch. As for the source of the Orbe in the Swiss Jura, it may be cited as a warning not to put implicit trust in even the most respectable-looking display of liquid crystal, for before making its appearance in the fairy vale which bears its name, it has ministered to all the requirements of a populous valley, though it has somewhat recruited its purity

in the pretty lake of Joux. Air and light may indeed be considered as more destructive of fever-germs than almost any amount of percolation, as is shown by the interesting account given in Ekin's "Potable Water," of the Lausen epidemic. It appears that a village of that name in the Canton of Bâle, was supplied with Water, apparently of the choicest kind, conveyed from a spring at the foot of a neighbouring mountain. Those who incurred this trouble and expense were apparently not aware that this spring was itself supplied from the Furler, a brook at the other side of the mountain, about a mile off; but this connection was made fatally manifest by cases of Typhoid Fever, which occurred first at some farms near the Furler, and then at Lausen, and was confirmed beyond doubt by a quantity of Salt thrown into the brook, and which became perceptible in the water of the spring. The experiment being repeated with flour, it was found that the straining undergone by the water in percolating the mountain, was such as to keep back the whole of the starch cells, though, fearful to think of, it could not arrest the progress of the far more minute typhoid-germs.

It is not generally known that we have nearer home an example of a second-hand spring, formed by the burrowing river which bears the appropriate name of Mole, and which empties itself into the Thames opposite Hampton Court.

Brooks and Rivers.

Generally our English Springs are but small, and from the moment they emerge from the ground to wind their course by the light of day, they are at the mercy of every tributary ditch. Thus by the time they coalesce to form

a river, their subterranean purity is spoiled by surface or subsurface-drainage, charged with the fertile impurities of a productive soil. Too often the brook which viewed from a distance gives life and poetry to the landscape, is in reality a receptacle for all that is furthest from poetical, and the bearer of disease and death. It has become a recognised fact that Milk contained in pails or pans that have been rinsed in the Water of a polluted Stream, may thus become instrumental in the conveyance of typhoid fever, but if any doubt remained, it would be dispelled by the sad experience acquired at Bristol, and of which I abridge the following particulars from the "Daily News" of the 8th May (1880).

For the third time within the past two years an outbreak of typhoid fever has been reported in Bristol as the result of using Milk contaminated with fever germs. There were eight persons down with the fever in five different houses, all of whom received Milk from one farm. Dr. Davies, the medical officer of Health for the city, visited the suspected farm, and was told by the farmer that he washed his cans in the mill-stream, indeed he used no other Water. Dr. Davies felt confident that the contamination was in the brook, and he determined to trace it. He went up the stream for a couple of miles when he discovered enough filth to poison a whole city, including carcases of animals that had died from disease, probably typhoid fever, which had of late been prevalent among stock in those parts.

As infinitely less than this would suffice to render the water of a brook unfit for consumption, and as that which has been proved to be possible gives at least some criterion of what may in a minor degree be considered as commonly probable, the question arises,—How is it that Rivers which are but the sum total of a thousand Streams of more or less doubtful pedigree, are regarded as a fit

and proper source of supply for thirsty populations, and have been really proved by long experience to be innocuous? This apparent paradox is satisfactorily explained by the oxidising action of the free Oxygen contained in the Water, and which is continually replenished from the Atmosphere as the Stream flows on, or by the aquatic vegetation.* It exercises on the Organic Matter suspended or dissolved, in company with which it travels, a consuming power which acts, not quite so rapidly as in a Carbon Filter, but with almost the same result.—Dr. Tidy thus sums up the evidence to this effect, at the conclusion of his Paper on River Water, read before the Chemical Society in April 1880.

"(1) That when Sewage is discharged into running water, provided the primary dilution of the sewage with pure water be sufficient, after a run of a few miles, the precise distance of travel being dependent on several conditions, the removal of the whole of the organic impurity will be effected.

"(2) That whatever may be the actual cause of certain diseases, namely whether germs or chemical poisons, the *materies morbi* which finds its way into the river at the sewage outfall, is destroyed together with the organic impurity after a certain flow."

With respect to the latter conclusion, it may be well to explain that without committing himself to an explicit admission of the germ theory, Dr. Tidy suggests that some of the supposed germs may be so low in the scale of life, as not to be shielded by vitality from the ordinary action of chemical laws, and that even germs not amenable to those laws, would after a flow of 10 or 12 miles suffer complete destruction by the bursting of their envelopes, owing to the powerful endosmic action of the Water in which they are immersed.

* "Vegetation constitutes an important means whereby Oxygen is set free in Water."—Dr. Tidy on River Water, page 301.

To the foregoing modes of riddance may be added another based on that universal Battle of Life, of which we may regret the necessity, but must admire the results. It strikingly manifests itself in the carnivorous appetites which largely characterise the population of our rivers, including examples of propensities peculiarly adapted to sanitary purposes. The Rat, the Crab, and the Cray-fish are noted for feasting on what they are most welcome to devour, and have active coadjutors in several species of fish, such as the Eel, the Bleak, the Barbel, &c. May not similarly some of the Infusoria which disport themselves by scores in a mere drop, be the appointed destroyers of Trichina Cysts, and other far more minute germs of noxious life, which through the nature of their covering or otherwise, would be safe from oxidation, and could be best disposed of by enemies that would eat them ?

Waterfalls and Lakes.

Two very distinct natural phenomena may be mentioned as contributing, each in its way, to the improvement of Streams.—

WATERFALLS, by favoring in a high degree the process of aëration, promote the oxidation of organic matter. A striking instance of this is related by Dr. Tidy, who in his visit to the falls of the Shannon, where that fine river descends nearly 50 feet in the course of a few hundred yards, was able to discern in that short distance a notable diminution of the brown tint acquired by the Water in the boggy region previously traversed.

LAKES are so admirably calculated to favor the subsidence of earthy impurities, that one is scarcely surprised even at the extreme transition from turbidity to limpidity

effected by the vast natural settling beds provided, for instance, for the Rhone by Lake Leman, and for the Rhine by the Lake of Constance, and south of the Alps, for the Ticino the Toccia and the Mincio, by the Lago Maggiore, and the Lakes of Como and Garda. One regrets that a similar benefit has not been conferred on the wild Doras which contribute so much to establish the character of the waters of the Po, or on the turbulent Adige, or on the muddy Brenta, but for which latter the Venetian Lagoons might be brighter than they are. But what one more regrets, is that the Rhone, the beau-ideal of purity as it issues from Lake Leman at Geneva, should so soon be soiled by the turbid Arve ; not without a long struggle to retain its azure limpidity, by keeping at least one half of its bed to itself.

In adding to the foregoing examples of lake influence those of the Limmat and the Reuss, respectively purified by the Lakes of Zurich and Lucerne one feels what a pity it is that one cannot include the Aar, more important than either. It traverses two lakes, of which the second, that of Thun, might be thought big enough for a settling bed, and yet a remnant of the greyish cloudiness it has derived from the glaciers of granitic regions, clings to it with provoking tenacity.

Colour of Rivers.

Many Rivers owe to the special character of their suspended impurities, an appearance in which is instructively represented the geological nature of their respective regions of supply.—Rivers that descend from the glaciers are often of a milky appearance. Rivers that flow through strata of Marl reddened by Iron, assume a red or yellow color, a striking example being

afforded by the river which flows into the Seine above Paris, and which bears the appropriate name of Marne (marl). The "Yellow Tiber" may be cited as a classical example, and the Red River and the Colorado may be pointed to in the regions of the far West, whilst the Rio Verde is equally significant, and China can boast of possessing both a Yellow and a Blue River. That waters proceeding from boggy lakes, or traversing a peaty country, are brown, has already been mentioned. Sometimes they are almost black to the eye, as in the case of the Rio Negro, on account of the quantity of vegetable matter which they contain.—It is interesting to pass from this to the beautiful example of purity presented by the River Loka in North Sweden, which is said to contain only one twentieth of a grain of mineral matter per gallon, owing to the hardness of the desolate region of Granite through which it flows. This perfection of purity may be better appreciated by a comparison with the River Jordan, which contains as much as 73 grains of solids per gallon.

The Abyssinian Pump.

Where Water of a good quality abounds in a bed of shingle, neither too sandy nor too much clogged with clay, good service may be rendered by the peculiar appliance patented by Norton, and which though of American origin, is called the "Abyssinian Pump," because it was supplied to the expeditionary force against King Theodore. The complete specimen presented to the Museum by Messrs. Le Grand and Sutcliff, dispenses with any elaborate description, and I will merely say that it mainly consists of a series of iron

tubes, varying from one to two inches in bore, according to the supply required, and about six feet long, made to screw on each other, so as to reach if required a depth of twenty-five or thirty feet. The lowest tube is pointed with steel, and drilled with holes for about eighteen inches from the point. It is driven vertically into the ground by means of a "Monkey," or driving-weight, which falls on a massive clamp. The position of this is raised as the tube descends, and the other lengths of tube are added as required. The presence of Water in the driving or "pioneer"-tube, as it is called, is announced by the sound of a plummet dropped into it, and when the supply seems well secured, an iron pump-head crowns the apparatus. It has many points in its favor, such as portableness, cheapness in comparison with well-sinking, and promptness of result where a pervious soil favors rapid driving. It is said that many a sandy desert on the sieve-like surface of which not a drop of Water can remain, has a substratum full of it. If so, a caravan provided with a light Abyssinian Pump, need not wait long for the coveted supply; though it would come up too thick with sand to be drunk without being either strained or allowed to settle. Even in the ordinary water-yielding gravel, the presence of too much sand appears to be the chief drawback. It necessitates the use of a settling trough, and after a time is apt to cause obstruction.

Artesian Wells.

It is easy to conceive a gravelly or sandy stratum full of Water, having an impervious bed above as well as below it, and to imagine this triple formation dipping down into the hollow of a broad geological basin; and it

is also easy to foresee that if a hole be bored in or near the middle of the hollow, right down through any superincumbent strata into the watery one, the liquid will rise through the vent hole to a height proportionate to the level it reaches at the sides of the basin.—Such is the principle of ARTESIAN WELLS (×), so called from the province of Artois in France, where they appear to have been first introduced.

It is obvious that the Water thus obtained, having been mainly kept to one stratum in its percolation, and that probably composed of sand or shingle, is likely to be little laden with lime salts; consequently soft, and valuable for many manufacturing purposes, finding special favor among brewers, though mostly too deficient in aëration to be a good Drinking Water. But its most interesting feature is the warmth it often derives from the low lying stratum from which it is drawn. You are aware that independently of the volcanic furnaces which exist in certain localities, there is a gradual rising of temperature as one descends towards the molten mass supposed to occupy the central region of our globe. This increase of temperature has been computed at about one degree of Fahrenheit for every sixty or seventy feet of descent.* The consequence is that Artesian borings, which reach unusual depths, if they send up anything at all, send up hot Water instead of cold. That at the slaughter-house or *abattoir* of Grenelle at Paris about 1800 feet in depth has a warmth of 82°, which, united with the fact of its being highly charged with Alkaline Carbonates, renders it peculiarly well suited to the sanitary purposes for which it is wanted. A boring

* The deepest mine in the world appears to be the Adalbert silver mine in Bohemia, which has now been excavated 1,032 metres deep. The heat is so great that it is no longer possible to dig further down.—"Echo," Sept. 19, 1881.

since completed at Buda-Pesth, in Hungary, has brought up from a depth of 3,200 feet, an outflow of 170,000 gallons per minute at a temperature of 165°. In this case however, something beyond the ordinary causes of subterranean heat must be at work, for the rise of temperature from the surface downwards gives the extraordinary mean of one degree for 30 feet.

Facts like these render somewhat conceivable the existence of many a Hot Spring of which the origin would otherwise seem altogether mysterious. One can imagine in the interior of a hill range, Water confined in a tortuous channel, which owing to the dipping of the strata, or to the direction of their fissures, is taken down to a depth sufficient for submitting it to the influence of volcanic action, or even to that of the earth's central heat, and is then brought up again to the surface. It is not even necessary that the outlet should be at a lower level than that from which the streamlet started, for with equal altitudes, the rising hot column would be lighter than the descending cold one.

WATER SUPPLY IN FOREIGN PARTS.

Hygiene like other things may be overdone, and gains nothing by it. Not long ago a traveller died in an Hotel on the Continent from Typhoid Fever occasioned apparently by drinking some Water from a suspicious source. It was a case that claimed a thorough investigation and well deserved to form the theme of sound hygienic advice ; but the broad-cast denunciations of the Drinking Waters of the Continent, to which this unfortunate incident gave rise in the Public Press, were too indiscriminate. Condemnations of transparent shallowness always spoil the effect of the deserved ones with which they are associated.

Of course sensible caution is always praiseworthy.—Persons who understand chemical tests will do well to turn their knowledge to account in any locality, British or foreign, of which the hygienic conditions are unknown to them. By merely providing themselves with solutions of Oxalate of Ammonia (×) and Chloride of Barium (×), they will be able to make a good approximate guess, not only of the prevalence of Lime Salts in the water supplied, but also of the relative proportions of Lime in the state of Carbonate and of Sulphate.*

But apart from chemical tests, the traveller should accustom his mind to habitual readiness of observation, and his judgment to freedom and flexibility. I need not say how much for purposes like these, a person who can fluently speak the language of the country he traverses, has the advantage over those who make their enquiries and investigations with dictionary in hand. A small amount of Geological knowledge added to these qualifications may sometimes supply useful warning of the probable prevalence of Lime Salts. The presence of a Gypsum formation is generally known through its usefulness for making Plaster, and is sometimes manifested, as in Derbyshire, by the offers for sale of articles of white or tinted Alabaster. Encrustations and Stalactites tell tales of Carbonate of Lime in excess. No one after visiting the calcareous caves of Eastern Belgium, as for instance, those of Han in the province of Namur, would think of trusting any spring of that neighbourhood, any more than he would the waters of the wonderful caves of Adelsberg in Carinthia, though they are preferred to any other waters in the world by the poor little blind reptile, the *Proteus anguinis*, which knows no better.—I remember, when a

* The precipitate obtained by the Oxalate indicates the total of Lime present; that by the Chloride, the amount of Lime as Sulphate, the difference represents Lime as Carbonate.

boy having been offered specimens of stalactite on my way to the celebrated cascades of Terni in central Italy. I did not then understand their hygienic warning, but have learned since that the River Velino which produces those magnificent falls, is highly charged with Carbonate of Lime. Its unfitness for being passed into our alimentary canal is sufficiently proved by the trouble it has given, over and over again, by filling with tufaceous rock the channels successively dug for it.

On the other hand Geology, or rather the kindred science of Physical Geography, may serve to allay unnecessary apprehension, by pointing to a peat formation as the origin of Water rendered suspicious by its brownish tint, and still more so by its rapid discoloration of Condy's Fluid. You are aware that though purely *carbonaceous* impurities do unfortunately affect this invaluable Test, they are not as a rule, noxious to health like the *nitrogenous* ones, and that indeed most detrimental to animal life, are those which animal life has engendered. Civilization is insanitary as long as it only promotes the gregarious tendency of our race, though it amply makes up for this when science arouses us to the consciousness of danger, and joins hands with Nature in providing a remedy. In many a lowland district where spring water can only be had by hauling it up from the bottom of a Well, habitations and their worst accessories crowd around, without a thought being entertained of the influence they may have on its purity ; or cottages are erected for convenience sake close along the banks of a rivulet, till the common benefactor becomes the common nuisance. On the contrary the traveller partakes with implicit confidence of the Water of a mountain spring, such as is often brought from a considerable distance to a Swiss hamlet, by pine trunks bored from end to end, and ingeniously attached to each other by circular dowels of

iron. Close to the trough hollowed from the stem of some king of the forest, it rises in an appropriate stand-post, and issues from an iron tube in a sparkling stream that is all the most fastidious Hygienist could demand.

It is however in large cities that one sees exemplified in the most striking manner the dangers of gregarious ignorance, and the triumphs of engineering skill.—I remember noticing at Florence in 1824, in the populous neighbourhood between the Via Vacchereccia and the Arno, a well in the middle of a court-yard surrounded by lofty houses. From each floor of these, a thin rod of iron descended to a large horizontal ring held by arched supporters at some height above the middle of the well. I should detain you too long if I were to attempt to make clear without a diagram, the exceedingly clever contrivance of long ropes and travelling pulleys, by means of which small metal buckets were shot down from the windows to the ring, lowered thence into the well, and rapidly hoisted back full of Water the way they came.—In my innocence of sanitary knowledge, I used to stand and admire. Now, my second thought, if not my first, would be—What kind of Water may this Well contain after having been for so many centuries open to all that descends from above, and exposed to noxious infiltrations from the earth all round, just as used to be the now-abolished wells of London ?—I had however seen worse at Naples in 1817. We occupied a flat in a house of which the front windows looked into a comparatively tidy street running into the Strada di Toledo, (now di Roma) whilst the back windows, including that of the kitchen, looked into a narrower street that was anything but satisfactory, being full of butchers' shops, where one could hear the meat constantly beaten to make it tender whilst it was yet fresh. At the end of the kitchen furthest from the window, and only a few feet from a

door leading to a closet of a very primitive description, was a cupboard door, on opening which one looked down into a dismal well running like a large ventilating shaft through the successive stories below and above us. Each had, like ourselves, a door, and a pulley-wheel, by which one of the usual metal pails could be let down into the dark abyss, and hauled up full of water. This probably was deliciously cool, and might be as sparkling as that of the Broad Street Pump of sinister memory, but I should be sorry to vouch for any further good qualities. Though I do not wish to draw conclusions from remembrances of so distant a date, I cannot help recalling to mind a severe case of inflammatory fever which occurred in our family during our Neapolitan sojourn, and which recurred during the above-mentioned stay at Florence.

The flood of sanitary reform has, I trust, long ere this swept away those domestic remnants of the dark ages. I judge of this by the progress made at Paris, where I saw in my youth a very different state of things from that which now exists. There were indeed already a certain number of public fountains supplied with water from noted springs, but they were inadequate, and it was thought a great improvement to supplement them with powerful steam engines, erected on each side of the Seine for pumping up the water. Unfortunately they were placed near the exit of the river from the City, of which the yearly increasing sewage became an intolerable nuisance. Such a state of things could not endure when the dawn of sanitary science grew to broad daylight. Not only were effective sewage works carried out, but under the authority of a powerfully constituted Municipality, and the able direction of the late eminent engineer, M. Belgrand, two abundant streams of carefully selected Water have been brought to the two portions of Paris respectively situated on the right and left bank of the

Seine. The northern or larger division, receives at an altitude of 354 feet, Water obtained from the Dhuys which rises near Château Thierry. The southern or lesser division, receives at a height of 262 feet, the tribute of the country between Sens and Troyes. The average amount of these supplies alone is reckoned at 16 gallons per head, per diem, of the Parisian population.

Works like these, or like those of Glasgow, are in some measure exceptional monuments of success, but a great many of the leading cities of the Continent have evinced an analogous spirit of emulation, and even Lausanne situated on a high hill * with a population of barely twenty-six thousand inhabitants, can boast of drinking, nearly 20 miles from their source, the pure springs of the uplands behind Montreux.

When the traveller is offered Water that has been brought from a distance with much trouble and expense, he may, as a rule (though not always, as shown by the Lausen supply) feel pretty well assured that it is worth drinking, and he may reserve his chemical tests for localities of which certain features look suspicious under the searching light of the hygienic lantern, or where agglomerated populations vegetate in the ignorance of olden times, or in the stolid listlessness of oriental fatalism.

Classification of Water Supply.

However valuable may be the senses of sight, smell and taste, as sanitary pioneers of the mind, it has been shown that their indications, especially those of the *palate*, which one might think the best judge of all, are not to be accepted

* The site of the Cathedral is 500 feet above the level of Lake Leman, that of the source at Pont de Pierre, which is 19½ miles from the reservoir at Lausanne, is about 900 feet.

with implicit confidence. This is confirmed by the following summary of classification borrowed by Parkes from the 6th Report of the Rivers Pollution Commissioners.

Wholesome	1. Spring-water . . .	Very palatable
	2. Deep well-water . .	
	3. Upland surface-water	moderately palatable
Suspicious	4. Stored rain-water .	
	5. Surface-water from cultivated land . .	*palatable*
Dangerous	6. River-water, to which Sewage gains access	
	7. Shallow well-water	

Statistics of Water Supply.

Respecting the quantity of Water that should be provided daily for each healthy adult, we cannot do better than follow the indications supplied by Dr. Parkes, from whom I borrow the following data.

"An adult requires daily about 70 to 100 ounces ($3\frac{1}{2}$ to 5 pints) of water for nutrition; but about 20 to 30 ounces of this are contained in the bread, meat, &c. of his food, and the remainder is taken in some form of liquid." Women drink rather less than men, children more in proportion to their bulk than adults.

The same author gives the following as a fair average of the quantities daily required by a typical individual.

	Gallons.
Cooking	·75
Fluids as drink, water, tea, coffee . .	·33
Ablution, including a daily sponge-bath which took $2\frac{1}{2}$ to 3 gallons . .	5·00
Share of utensil - and house-washing . .	3·00
Share of clothes - washing	3·00
	12·08

A bath taken once a week and requiring from 40 to 50

gallons would raise the foregoing daily average by 6 or 7 gallons.

No one would be surprised to hear that very considerable differences exist, not only between single cases, but also between the habitual standards of requirements and supply, in various localities of Town or Country, or in different countries and among different races. Even in some English Villages, either from a difficulty of obtaining Water, or from the want of a due appreciation of cleanliness, the daily quantity used descends to 4 or even 2 gallons per head. Respecting Towns, the following data may suffice :—Professor Church says that the London District, with about 4 millions of inhabitants, receives from the Water Companies a daily supply of 114 millions of gallons, which would make 28½ gallons per head per diem.—The following statistics of daily Water-supply per head of population are from Parkes :—

	Gallons.
Glasgow	50
Edinburgh	35
Paris	31
Liverpool	30
Sheffield	20
Derby	14
Norwich	12

The following extracts are taken from the official Report on the Water Supply of the Metropolis for 1880 by Prof. Frankland, F.R.S. &c.

"The inner circle of London was supplied as usual by eight companies, with an average daily volume of 142,190,921 gallons of water, being an increase of no less than 7¾ millions of gallons upon the previous year. Of this 71,879,776 gallons were sometimes grossly polluted by sewage matters ; 61,765,034 gallons were occasionally so polluted, but to a less degree ; whilst only 8,546,112 gallons were uniformly of excellent

quality for drinking. The average daily volume supplied per head of population was 34·1 gallons. This is greatly in excess of what is required, and indicates gross waste; but whilst the quantity was abundant the quality of the river water was generally indifferent and often very objectionable.

"It would be an incalculable gain to the Metropolis, promoting both the interests of temperance and of public health, if the polluted river water which now forms the main supply, were replaced by the palatable and wholesome water obtainable from springs and deep wells sunk in the chalk. Water of the latter character is now supplied only to a small portion of London by the Kent and Colne Valley Companies and by the Tottenham Local Board of Health, and the Tables attest the uniform and excellent quality of this water for drinking purposes. This pure spring-water is everywhere abundant in the Thames basin. In dry seasons it constitutes the sole supply of the Thames and the Lea.

"The natural filtration which the Kent, Colne Valley, and Tottenham deep well-water undergoes through an enormous thickness of chalk, renders artificial filtration unnecessary, all the 36 samples of deep well-water being perfectly clear and bright."

CHAPTER III.

A. FERMENTATION.

General Remarks.

The name of Fermentation is given to certain remarkable changes wrought by Nature in the composition and properties of Organic Compounds, and which it is more easy for Science to utilise, and even to imitate, than satisfactorily to explain. They are of vast hygienic importance, both as producers and as destroyers of Food. In support of this, I need only remind you that the conversion of Barley into Malt is called Saccharine Fermentation, because it produces the kind of Sugar called Glucose; and that this Glucose, or Grape Sugar, when dissolved from Malt in the form of Sweet-wort, or contained in the juice of the Grape and other fruits, or in endless other products, undergoes under favorable circumstances, another remarkable transformation, which is termed the Alcoholic Fermentation, because the result is the production of Alcohol or Spirit of Wine.*

Similarly, a third process called the Acetic Fermentation, transforms Alcohol into Vinegar. A fourth,

* This product is properly speaking only one of the many "*Alcohols*" established by modern Chemistry, but custom has sanctioned the use of the word "Alcohol" in the singular, for denoting Ethyl Alcohol, or Spirit of Wine.

more comprehensive in its sphere of action, merges the most varied organic products in a common doom of decay, and may conveniently be denominated the DESTRUCTIVE FERMENTATION.

There are incidental Fermentations which do not lie in the above direct line of transformation, but which are best studied in connection with it, and the same will be our most convenient course as regards the various laboratory operations devised, some of them with wonderful success, for replacing the processes of Nature.

Two chief modes of action manifest themselves in the natural Fermentations. The one is a mere combination of the Oxygen of the air with one or more of the elements of the substances acted upon. The other to which the term *Fermentation* more essentially applies, is a more considerable change in the constitution of the substance, which not unfrequently involves the assimilation of the elements of water, and takes place under the mysterious influence of a so-called FERMENT, that seems to bring about the disturbance by its mere presence. Ferments are mostly low forms of Vegetable Organism, belonging to the Fungus or Mushroom Tribe.* In some cases however it is difficult to discern any definite form of growth, and this is the case in the Saccharine Fermentation, with which we will now proceed to make a closer acquaintance, taking the others in succession, together with their respective kindred.

* Liebig and some others contest the influence of vitality as the chief agent in the phenomena of Fermentation, but the researches of Blondeau appear to have established a preponderance of opinions in favour of admitting that influence.—Roscoe in his "Lessons on Elementary Chemistry," asserts that in the Butyric Fermentation, the Vegetable Fermenting Agent is replaced by animalcules having the extraordinary faculty of living in an atmosphere of Hydrogen; but this does not appear to be as yet generally accepted.

Saccharine Fermentation.

We will take the usual example of a grain of Barley intended for Malting. Like other grains, and especially those of the Cereals, it contains, besides a large proportion of Starch and a small one of Glutin, a minute quantity of vegetable Albumin, which is prone to pass into a state of decay under the joint influence of warmth and moisture. These are precisely the conditions to which a Barley-corn is submitted, naturally when it is sown in spring weather, and artificially in the malting chamber. Whether or not the Fungus germs or sporules, which are supposed to be everywhere floating in the atmosphere, settle in the softened Albumin urging on a decomposition which they profit by, it is certain that from the fermenting magma or ferment thus produced, and which in this case takes the name of *Diastase*, a feverish excitement spreads through the whole starchy substance of the grain, which without losing any of its components begins arranging them in a different way. Thus the Starch (×) is converted into Dextrin or British Gum (×). A further re-arrangement of atoms accompanied with the assimilation or absorption of a certain quantity of the elements of Water, converts the Dextrin into Glucose or Grape Sugar (×). Dextrin and Glucose are both soluble in Water. Consequently a syrupy nutritious pap now fills the grains of Barley, the embryo or germ situated near its point, awakes to active vitality, sucks in the welcome food thus prepared for it, and rapidly develops in the form of a little green shoot. In other words our Barley *germinates.* This germination would soon show its results in the form of a rootlet, a stalk, and an approximation to leaves, but as it is not this development that the maltster desires, he soon transfers his

moistened Barley from the thick beds or *couches* in which Fermentation has been promoted, to the drying kilns in which it is suddenly stopped. I must leave for the account of Brewing, to be given in its proper place, the details of manipulation by which the different varieties of Malt are produced. It will suffice for the present to point to the Sweet-wort (×) obtained from the Malt in the mash-tun, as affording conclusive evidence of the transformation of the Starch of the Barley into Glucose.*

A result identical with that obtained by the natural Saccharine Fermentation is obtained in the laboratory by boiling Starch with dilute Sulphuric Acid, a fact which, as mentioned elsewhere, is rather peculiar, if one considers that the change effected is an addition of the elements of Water, whereas the effect produced by Sulphuric Acid, when strong, on vegetable substances in general, and consequently on Starch itself, is to deprive it of the elements of Water, reducing it to a black carbonaceous magma. It is by the Sulphuric Acid process that are obtained the large quantities of Glucose used for various manufacturing purposes.

Alcoholic or Vinous Fermentation.

The Brewer before transferring his Sweet-wort to the vats used for the Alcoholic Fermentation, flavors it with Hops, but this addition, intended to improve the taste and promote the preservation of his Beer, is of course not the cause of the transformation of the Glucose to the condition of Alcohol. Diastase might start this second Fermentation as it did the first, but a less microscopic

* This transformation may be shown simply as follows :—

$$\begin{array}{ccccc} \text{Starch} & + & \text{Water} & = & \text{Glucose} \\ C_6H_{10}O_5 & + & H_2O & = & C_6H_{12}O_6 \end{array}$$

agent is forthwith added,—a special vegetable ferment composed of a multitude of living cells measuring from $\frac{1}{7500}$ to $\frac{1}{2500}$ of an inch in diameter, which form by their accumulation the remarkable substance known as Barm or YEAST. These cells are gifted with an exceedingly active and stirring vitality. If a few of them be placed under a microscope in a little sweetened water containing nitrogenous matter, they will at first present the appearance shown in Fig. 1 (×) of the suspended Diagram ; but in the course of a few hours they may be seen to throw out buds or offsets, in the manner exhibited in Fig. 2 (×). When once commenced, the development is often very rapid, and after nine or ten hours you may see, as in Fig. 3 (×), the original cells almost lost in the midst of their multitudinous progeny.

Two distinct species of the Yeast Fungus have been determined, namely the *Torula Cerevisiæ* which is the larger of the two and the one represented on our Diagram, the other, the *Penicillium Glaucum.*

Itself the offspring of Alcoholic Fermentation, Yeast is the most active means for promoting it in glucosic solutions, provided nitrogenous matter be present, as in sweet-wort, to favor its growth ; for it is itself essentially of nitrogenous composition. But here as I have told you to be generally the case with Ferments, the agent of transformation does not take anything from the substance transformed. What occurs is only a splitting up of the component molecules of Glucose into two portions, respectively forming Carbonic Acid and Alcohol, (×) neither of which the Yeast-plant profits by.*

As Common Sugar, or Saccharose, is sometimes used

* The process may be chemically represented as follows :—

Glucose	=	Carbonic Acid	+	Alcohol
$C_6H_{12}O_6$	=	$2\,CO_2$	+	$2\,C_2H_6O$

for the production of Alcoholic liquors, it is well to remark that it is converted into Glucose before undergoing the above transformation.

This Fermentation requires a temperature between 70° and 150° and the presence of air to begin with, though the operation once started can proceed without air.—All favorable circumstances are combined in the fermenting vessels of the Brewery, and hence a rapid production of Yeast, and an evolution of Carbonic Acid so considerable as to be a source of danger to the careless. This same Carbonic Acid is however turned to good account in the production of sparkling Ales, which being bottled before the Fermentation is completed, absorb the imprisoned gas.

The same principles of Alcoholic Fermentation apply in the production of Wines from the juice of Grapes, of Cyder from that of Apples, and of Perry from that of Pears. The sap of certain Palm-Trees, and other sweet juices, are similarly made to ferment, and Honey mixed with Water is converted into that *Mead* in which our ancestors used to delight ; whilst the Tartars prepare an intoxicating drink with mares' milk, taking advantage of the Milk Sugar which it contains.

DISTILLED LIQUORS may be obtained from any materials which have undergone the Alcoholic Fermentation, by putting them in a still, applying a gentle heat, and collecting the vapours in the condenser. It is thus that Brandy is obtained, either from Wines that one does not wish to keep, or from the *marc* or residue of the crushed Grapes, from which the *must* or juice has been drawn. Gin and Whiskey are prepared from fermented Malt, Rum from fermented Molasses and Sugar refuse. Perhaps the most injurious of all commonly used is Potato Brandy, produced by the successive conversion of the starchy matter which abounds in the Potato, into

Glucose, and then into Alcohol, without eliminating a very acrid essential oil.*

It will be seen in treating of Bread-making or Panification, that the successive conversion of Starch into Glucose and Alcohol, is one of the features of that process, the concomitant production of Carbonic Acid in the latter stage, being the cause of the rising of the dough.

Acetic Fermentation.

There is perhaps no more striking proof of the extraordinary disturbing power of fermenting agents, than the fact than even Alcohol, the very fluid which is used more than any other for preserving substances from decay, is when diluted and submitted at a lukewarm temperature to the influence of a ferment, actually changed into that Acetic Acid which was introduced to you in the review of Proximate Organic Constituents, as the acid principle of Vinegar. That this transformation was known in remote antiquity,is shown by the 3rd verse of the 6th Chapter of Numbers, in which Moses forbids the Nazarites to make use of Vinegar made from Wine or other strong drinks.

It is still from Wine that the best Table Vinegar is obtained, and this term *Vinegar* is indeed derived from the French word *Vinaigre*, itself a compound of *Vin* or Wine, and *aigre* which means sour. Certain establishments are it appears kept open by our neighbours for the reception of Wines which, through nature or misfortune, have acquired an incorrigibly sour temper. They are not only encouraged to indulge further in their propensity

* This acrid body termed Fusel or Fousel Oil, mainly consists of Amyl Alcohol, the fifth of the series of which common Alcohol is the second.

by keeping them at a temperature of 80°, but excited by the influence of a preponderating quantity of Actual Vinegar, with which they are mixed in barrels contrived to admit the Air, and often containing moreover a small quantity of an appropriate ferment ; though the albuminous matter contained in the Wine, would if necessary, soon supply one. As the proportion of the Vinegar largely exceeds that of the Wine, no wonder that at the end of a week's time, the latter becomes as sharp as its associate, and ready to assist in perverting a fresh quantity of its own kindred.

Beer is quite as apt as Wine, if not more so, to become excessively tart, and worthless as a beverage; but Vinegar made of it would be very poor, not to mention the objection of the hop flavour, and the greater part of our British Vinegar is obtained from a stronger infusion of malt, specially prepared, as will be duly explained in treating of Vinegar as a Condiment. Even a weak solution of Sugar may be turned into a kind of Vinegar through the action of Yeast, or still better of the peculiar low form of vegetation (×) called the Vinegar Plant (*Mycoderma aceti*).

In a chemical point of view, the process of Vinegar-making, or *Acetification*, divides itself into two stages, in both of which the Oxygen of the Air is the active agent.* In the first stage it carries off in the form of Water, a mole-

* Alcohol . . .	C_2H_6O
Aldehyd . . .	C_2H_4O
Acetic Acid . . .	$C_2H_4O_2$

Or in proportionate weight :

	C	*H*	*O*
Alcohol . . .	12	3	8
Aldehyd . . .	12	2	8
Acetic Acid . .	12	2	16

cule of the Hydrogen of the *Al*cohol, which thus *de-hyd*rogenised, takes the name of AL-DEHYD (×). The second stage is simply an addition of an atom of Oxygen to the Aldehyd, which thus oxidised becomes ACETIC ACID (×).

Independently of the production of Acetic Acid by the destructive distillation of Wood, which is of course no fermenting process, there are examples of its being produced through actual Fermentation from other bodies than Alcohol. Thus the sourness of soup and other gelatinous solutions which have been allowed to stand too long, is attributed to Acetic Acid. On the other hand, other Organic Acids are also produced by Fermentation. Thus when Milk turns sour, which it does much quicker than Wine or Beer, the influence of its peculiar ferment converts its saccharine ingredient into LACTIC ACID (×). The chemist finds matter for interesting study in the fact that the per-centage composition of Milk Sugar and Lactic Acid may be considered as identical, so that if one could find a retrograde ferment, there would be no difficulty in making sour Milk turn sweet. Lactic Acid presents itself as you see in the form of a syrupy fluid.—Closely allied to it, but rather more oily, is BUTYRIC ACID (×), which is produced when Butter and other fatty matters undergo that peculiar Fermentation known as *rancidity*. It is worth remembering that this rancid Butyric Acid, which singularly enough exists in Tamarinds and in certain Beetles, is soluble in Water, so that rancid Butter may to a considerable extent be rendered palatable again by copious washings ; though it must not be expected to regain the fragrancy and flavor originally imparted by peculiar essential oils.

Destructive Fermentation.

We now come to that fourth form of Fermentation, which, because it merges Organic Products in a common doom of *decay*, I proposed to denominate Destructive Fermentation. Now properly speaking, every chemical transformation in which one body ceases to exist, and another very different one is produced, may to a certain extent be considered as *destructive*, and in that sense, the successive transformations of Starch into Sugar, Alcohol, and Acetic Acid, are unquestionably destructive processes ; but they at least give a *quid pro quo*, and for each body that disappears, we are presented with another equally interesting, whereas Destructive Fermentation ends mostly in a congeries of nondescript materials, having little value except as a starting point for fresh combinations.

The various forms of Destructive Fermentation may as a rule be considered as so many oxidising processes, though it has been found by Gay Lussac, that after being fairly started by the Oxygen of the air, they can manage to go on without it. They divide themselves however into two categories :—The first category which some chemists do not include among the Fermentations, is commonly known as the "Putrid Fermentation," and is, generally speaking, characterised by the emission of fœtid and nauseous odors ; although here considerable ambiguity arises from the diversity of ideas which prevails in matters both of smell and of taste. One guest will pronounce a dish of grouse just as high as it should be, whilst another will find it decidedly repulsive. A similar case is presented in some countries by certain small home-made cheeses, which on account of the deficiency of natural fatness and flavor, are allowed to

ripen till their taste can only be relished through habit, whilst their smell is simply intolerable.

The second category is inodorous mouldering Decay, which being in reality a kind of slow combustion, has received from Liebig a name expressive of the fact, *Eremacausis.* That this *combustion* is not always so slow as to lose altogether its characteristic feature of production of Heat, is satisfactorily proved by the use made of it by gardeners who obtain warmth well suited for stimulating the growth of plants, not only from accumulations of stable manure, but even from heaps of decaying leaves, which suffice for forcing Sea-Kale, Rhubarb and the like. On the other hand, very unsatisfactory proofs are afforded by the destruction of hayricks set on fire through the fermentation of hay insufficiently dried, and by the far more disastrous loss of vessels at sea through carrying materials susceptible of similarly engendering "Spontaneous Combustion." For occasioning it through dampness, large masses are required. Much smaller quantities suffice sometimes where the materials are greasy, and in fact the oxidising process is in such cases so rapid as to lose altogether the character of a Fermentation.

As might be expected, substances containing Nitrogen, succumb more readily than purely carbonaceous ones to Putrid Fermentation, and their destruction is more often accelerated by living organisms, animal and vegetable, which as soon as the equilibrium of their constituents is disturbed by Oxygen, attack and feast on them. You see represented on a vastly enlarged scale (×), a fungus (*Botrytis vulgaris*) which under the name of Mould springs up so plentifully from Paste which has been kept too long, and which on account of its Gluten affords it appropriate nourishment.*

* The name of Mould is equally given to *Penicillium glaucum, Mucor mucedo*, and *Aspergillus glaucus.*

The least visible however of the living parasites of decay are the most dangerous, and sometimes it is difficult to decide whether one should ascribe to zymotic influences, or to the production of chemical poisons, the virulent effects produced on the system by eating tainted Meat or Fish.

The attention of Professors of Medical Jurisprudence was not long since called to the fact that violent poisons of the alkaloid class, susceptible of being confounded with some of the most deadly of the vegetable alkaloids, and by some called *Ptomaïnes*, are occasionally produced during the decomposition of human remains. Fortunately a distinctive test, as convenient as it is promising, has lately been discovered. *Ferri*cyanide of Potassium produces Prussian Blue with per-salts of Iron by the aid of the Ptomaïnes, which some say is not the case with the Vegetable Alkaloids. The cases of blood poisoning through virus accidentally imbibed at dissections, seem on the contrary to manifest a zymotic character, and the same may be said of the appalling effects of that most fearful of savage devices, the poisoning of arrows in an analogous way, by the native warriors of the Australian regions.

Very different in character is *Humus* or Vegetable Mould (×),* that soil of the forest, that dark brown friable product, or rather mixture of products, which is so peculiarly favorable to vegetation, and which itself results from the Destructive Fermentation of vegetable matter. The powder of similar colour in the next bottle is Humic Acid (×), the chief principle of Humus, obtained by boiling it with an alkali, treating the liquor with an acid, and drying the precipitate.† This Humic

* Called by some authors Humin, Gein, or Ulmin.

† Strictly speaking Humic Acid is a mixture of certain ill-defined Acids, which have been called Humic, Geic, and Ulmic. To these

Acid is but a very tame and uninteresting inmate of a chemical laboratory, but in that of Nature it diligently performs a highly important task for our benefit. It is just strong enough to lay hold of the Ammonia which is being constantly produced by the decomposition of animal matter, and yet weak enough to yield it up without difficulty to the plants, into whose roots the Humate of Ammonia penetrates, dissolved in the moisture which they absorb. Thus by an admirable dispensation, effete animal matter is supplied to Plants, in order that they may do with it what Animals themselves cannot do, namely, raise it once more from the inorganic to the organic form,—from the lifeless to the living.

One cannot often draw any conclusion as to chemical constitution from colour ; but the darkened tint of Humus, as compared with the original leaves or wood, correctly indicates an increased percentage of Carbon, and in fact the action of the Oxygen appears to be chiefly spent in carrying away the Hydrogen.—The imagination takes up the clue, and reviews with interest the gradual transition by which accumulated masses of vegetable spoil may, through countless ages, and under varied circumstances of pressure, moisture and heat, have passed to the various products, at different stages of Destructive Fermentation, of which the Carbon percentage is given in the following list according to Roscoe :—

Peat from the Shannon	60·02
Lignite from Cologne	66·95
Earthy Coal from Dax	74·20
Wigan Cannel Coal	85·81
Newcastle Hartley Coal	88·42
Welsh Anthracite	94·05

some authors add Crenic and Apocrenic Acids, which are interesting on account of their being found in mineral springs, to the efficacy of which they are supposed to contribute.

B. PRESERVATION OF FOOD.

N.B. The articles adverted to in this section are so numerous, that it has been deemed inexpedient to exhibit duplicates of the specimens that will be respectively displayed in their proper places among the Food Resources supplied by the Animal and Vegetable Kingdoms.

The insufficiency of home produce for home consumption, which is manifested on a larger scale in the United Kingdom than perhaps in any other country, has given rise of late years to an enormous development of old means, and to the discovery of many new ones, for enabling provisions to be kept a length of time, and for facilitating their conveyance to a distance. These means are mainly referable to two divisions. The one consists of devices for obviating the three chief causes which promote Destructive Fermentation, namely Warmth, Moisture and Air. In the second division we see chemical agents, called ANTISEPTICS, from Greek words signifying *against corruption*, imparting a tougher nature to certain ingredients of Food particularly prone to decomposition, or otherwise warding off the development of animal or vegetable parasites, which are ever ready to attack the weak points of an unprotected prey, and to accelerate its ruin.—We may be led to notice subsidiarily, the means of purification by which Food that has become tainted, may, within certain limits, be restored to usefulness. As for the methods commonly employed for maintaining provisions in a fresh state for short periods, it will be seen as we go along, that in most cases they are but milder adaptations of the agencies employed in a stronger degree for protracted preservation.

Preservation by Cold. (×)

Every one knows how much more rapidly Meat, Poultry, Fish, and the like, become tainted and spoilt in hot weather than in cold. So much is this the case, that in tropical countries it is generally difficult to keep Meat long enough to get rid of the toughening rigidity which pervades muscular fibre after death, and which in our climate takes one or more days to subside. Hence the value of a cool larder, which makes a very great difference in the time for which provisions may be kept. The use of Ice-safes and analogous coolers of various dimensions and ingenious construction, has greatly increased on account of the vastly improved supplies of clean ice.* Besides being brought from Norway, in lieu of its former more distant source, the Wenham Lake, it is, thanks to a variety of admirable scientific inventions, now supplied by artificial means still cheaper than it can be imported. One of these devices consists in the sudden release of air condensed under a pressure of about 60 lbs. to the square inch; in another Ether, of which the refrigerating effects, when projected for anæsthetic purposes in the form of spray, have been already adverted to, has been employed on a large scale for reducing to a low temperature a solution of Chloride of Calcium, by the circulation of which through Water the latter is congealed. But particularly ingenious is the plan for utilizing the peculiar properties of Gas Ammonia. After having been driven by warmth from its solution in water, and condensed by its own pressure into the liquid state, it is made to effect the desired refrigeration by a sudden return to the

* For illustrated descriptions of a few leading varieties of Ice-safes, Refrigerators and the like, see the special department of the Official Catalogue of the Parkes Museum.

gaseous condition. It is as promptly collected again in aqueous solution by merely giving it an opportunity of gratifying its affinity for Water. In these processes the secret of pecuniary success lies in the ingenuity with which the machinery of the Refrigerators is devised, and the perfection with which they are constructed, so that an expensive article becomes available, with scarcely any loss, for doing duty over and over again.—When I tell you that one of the London Companies supplies artificial Ice wholesale at 2/- per cwt., that is to say, at the rate of less than a farthing per pound, you will easily understand that through these means available in all climates, Ice has become for Europeans in hot regions, through constant habit, something more than a luxury,—an almost indispensable condition of the maintenance of health.

Still more extraordinary are the feats accomplished by Refrigerators as trans-oceanic purveyors of fresh Meat. By their means refrigeration can be kept up, or to speak more correctly, the temperature may be kept down, in a fire-impelled steamer, during its hot progress through the Indian Ocean and the Red Sea. The consequence is that, whereas formerly much was thought of bringing Fish packed in Ice from our own northern ports to the Metropolis, one may now eat Meat brought *cold* all the way from Australia.

It may be well to remark that, according to reliable accounts, a uniform temperature several degrees above the Freezing Point, say 38° F., is sufficiently cold to prevent harm ; and some of the best means of importation from North America appear to be founded on that principle, applied in the form of cold currents of dry air.*

* 6000 salmon, placed during the summer in a Refrigerator on this principle, at the Hudson's Bay Fishery, reached London in such good condition as to be equal, when thawed, to fish freshly caught.

There seems to be no foundation for the idea that frozen Meat is of little value. In Canada and other regions, where one can reckon on a sharp frost for an uninterrupted period, it is a regular practice to lay up a winter store of Meat, which is hung up in a suitable place, in large joints or quarters, from which pieces are sawn off as occasion requires. If the precaution be adopted of thawing them by immersion in cold water, and not keeping them long when thawed, no ill result whatever accrues from this highly convenient mode of preservation.

Preservation by Exclusion of Moisture. (x)

Manifold and admirable are the natural devices for keeping dry the seeds of plants till the time for their germination is at hand, and our forefathers only borrowed a leaf from the book of Nature in guarding from moisture their Cereals, Pulse, and other analogous produce. Through drying fodder for their cattle, we may fancy them learning to dry pot-herbs gathered in summer, for rendering them available at all seasons. The desiccation of succulent fruits was a further step of notable importance, exemplified by the dates, raisins and other products of warm climates dried by the heat of the sun, or the apples, pears, and other hardy fruits which, dried by artificial heat, are a welcome help where long winters and deep snow materially reduce vegetable resources. I have seen stores of this description prove very useful in alpine regions, though I believe that in many cases, they might be improved by a more careful selection of the horticultural varieties best suited to the several localities. Many of these places seem capable of

producing kinds equal in quality to the Totness squat Apples, the Normandy Pippins, or the more delicate article imported to this country from America, under the name of Apple-rings or Chips. It is not everywhere that Plums can be grown equal to those of the banks of the Loire, but many places might improve their export of Prunes by stoning them, a process which has several advantages.

Chestnuts are as a rule indifferently represented in this country, a large proportion of those brought over being worm-eaten, or otherwise defective. This highly nutritious fruit is, however, so easily kept for a time when sound, and forms so convenient a freight, that our yearly supply might with a little management be greatly improved, independently of the modes of preservation practised in the countries where it forms a staple article of popular sustenance. In the north of Italy, I have seen quantities kept in a dried state without husk or skin ; but they are hard, troublesome to cook, and unsatisfactory. The form of flour used in some districts is a great improvement ; it makes a superior substitute for the maize polenta, and it is a pity that only an inconsiderable quantity is imported into this country in small packets of choice quality for dainty puddings. The select Chestnuts, strung in large chaplets, and sold at Milan ready for eating, under the name of "Cugni," are prepared by a process which gives them a peculiar sweetish flavour.

One of the most interesting articles in the Food Department of my Economic Museum, was a sample of the dried Potatoes known in Peru as *Chuños*, presented by my kind friend Prof. Faraday. Their small, smooth, rounded knobs united thorough dryness with so clean and pure a whiteness, as to suggest the gently desiccating influence of a low barometric pressure on some high level of the Andes.

Less inviting in appearance, but extremely useful, are the Potato Chips obtained by drying sliced Potatoes in an oven. In fact, wherever Potatoes are largely cultivated, a drying apparatus, of simple and cheap construction, should be at hand, for rescuing at a trifling expense, crops which, either before or after being got in, betray signs of disease.—The various processes for which patents have been taken out, include Potatoes in a granulated form, reduced to flour, made into vermicelli, &c.

About 30 years ago Masson's plan of preserving vegetables by drying and compressing them, opened the way to a series of improvements which have gradually brought this resource to a high state of perfection combined with cheapness. Among the most noted names in the long list of patentees are those of Devaux, Chollet and Co. Some idea of the importance of this process for maritime and military purposes, may be gathered from the fact that vegetables are thus reduced to one-seventh of their original bulk, and that a cubic yard supplies rations for 16,000 men. At the same time, the best manufacturers, and notably Makepeace, have succeeded in preserving both colour and flavour.

The principle of the abstraction of moisture has long been applied to the keeping of Meat, though latterly other means of preservation have obtained the preference.—Jerked Beef, apparently the *Charqui* of South America, is prepared of various qualities by the herdsmen of the Pampas, who cut the freshly killed meat into strips, which is called *jerking* it, dip them in brine, or pile them with salt for 12 hours, and then dry them by exposure to the sun for two or three days. Sometimes the result is pounded into a paste for being kept in jars; or maize meal is added, and the paste is pressed into leather bags for the use of travellers. Generally when dried meat is kept alone, there is a loss of flavour. The preparation of

Pemmican from the flesh of the Bison and other animals, by the huntsmen of the northern wilds of America, appears to be rather more elaborate. The meat, well dried in small slips, is pounded, and mixed with about half its weight of fat, sugar and spices being sometimes added, or other ingredients at pleasure. The practice of keeping it in skins tends probably to protect the fat from rancidity. In other regions, various processes are adopted, drying being a general, and pounding a frequent, feature.

We shall likewise find drying an important feature in the antiseptic processes known as *Dry-salting*, and chiefly employed for preserving Fish, or the flesh of the Pig. Meat dried and reduced to a powder has been introduced in the preparation of Biscuits like those manufactured by Peek, Frean and Co., and in that of Blumenthal, Chollet and Company's Soup Tablets.—Liebig's Extract of Meat derives its keeping quality from the abstraction of moisture; other considerations which it involves will be dealt with in another section.

An interesting example of desiccation applied to a single Proximate Constituent of Food is afforded by Véron's Granulated Gluten, which was exhibited at Paris in 1855, and for which a nutritiveness considerably surpassing that of the best Italian Pastes, seemed to claim a more extensive patronage than appears to have been hitherto bestowed on it.

You have seen that White of Egg may be preserved, though not specially as a Food Article, in thin yellowish scales, obtained by drying it without coagulation at a temperature of 122°. But the Yolk cannot be so easily preserved, on account of the fatty particles it contains, which are liable to rancidity. *Condensed* Milk with a certain proportion of Sugar, has become a source of wealth for several Swiss and English Companies, and has proved

an immense benefit to mariners and to mothers. The most efficient plan appears to be to evaporate the Milk in large vacuum pans, at a warmth not exceeding 100°, and to add to the condensed product about one-third of its weight of Sugar.

Preservation by Exclusion of Air.

As hinted in treating of Destructive Fermentation, that change for the worse can, when once started by the Oxygen of the Air, dispense in some cases with its further presence ; but as a rule, that presence is an important factor in the process of decomposition, and proportionate importance attaches to the means by which Air can be excluded from putrescible substances which one desires to preserve. In many instances, such as the preservation for a limited period of Potatoes, Mangold Wurzel, and the like, long mounds of earth are in our climate a sufficient protection both from air and frost. Where severer winters prevail, recourse is had to deep pits, beyond reach of atmospheric influences, or, still better, to caves in the mountain side, so selected as to secure uniformity of temperature, as well as constant immunity from damp, to the protecting bed of earth. Dry sand or ashes in a dry cellar are all that is generally provided for the winter store of Carrots, Parsnips, Turnips and the like. Boxes full of sand are sometimes thought good enough for Walnuts and Chestnuts, whilst more delicate fruits, including Grapes, are packed in saw-dust, in which indeed they may be conveyed, without injury, to a distance.

It is not easy to say how long Housewives have known the art of bottling certain fruits without sugar, but it is

certain that towards 1808, the Society of Arts gave a considerable impulse to this branch of domestic industry by awarding a premium to Thomas Saddington for preserving fruit in Water. In 1810, M. Appert of Paris, ignorant apparently of what had been done in England—a fact sufficiently accounted for by the unsatisfactory political relations which existed at that time between the two countries—brought out an elaborate work on the principle and practice of Preservation by Exclusion of Air. Soon after, a patent was taken out in England by Messrs. Donkin and Co., introducing the important novelty of Canistered Meats.

The processes which have gradually resulted, may be briefly summarised under the following three heads :—Dry-bottling, Wet-bottling, and Canistering, also called Canning or Tinning.

DRY-BOTTLING. Various Fruits, and especially those which like green Gooseberries, have a good protective skin, may be preserved when gathered dry and got ready without abrasion, by putting them into dry bottles, and exposing these for half an hour or so in a water bath, to a heat of about 165°, or by gradually raising the temperature of the bath to the boiling point. In this so-called *scalding*, the coagulation of the Albumen, the most putrescible ingredient of the Fruit, is the main object of the operation. Formerly a brimstone match was burnt in the bottle before introducing the fruit, with a view to the antiseptic properties of the sulphurous fumes, but it would be a great mistake to make a similar use of the matches of the present day. Prescriptions vary as to the corking of the bottles, which by some is ordered to be done before, by others after, the scalding. At all events they must be hermetically sealed.—It is evident that in this process, the Air in the vessel is reduced rather than exhausted ; nevertheless for moderate periods

and suitable Fruits, this mode of preservation has its advantages.

WET-BOTTLING. Sometimes a bottle of Fruit that has been scalded in the manner just explained and allowed to cool down, is filled up with cold water previously boiled to deprive it of its Air, but the following process appears to unite more elements of success.—Boiled Water is poured into bottles nearly full of raw Fruit, covering it enough to allow of its swelling without becoming uncovered. The bottles are placed half-way up their necks in a water-bath, hay being packed between and under them to steady them, and prevent breakage in boiling. The kettle, which is a broad and shallow one, is gradually heated to ebullition, during which time bubbles of air are seen to rise from the Fruit. Their expulsion being completed, and a little more boiled Water added, if necessary, a layer of Olive Oil is gently poured on, and the whole allowed to cool, after which a bung or piece of bladder completes the operation. I am now describing a typical example of the domestic process, assuming the bottles to be intended to stand upright. To render them portable, pure melted Paraffin might be substituted for Oil. It must of course be the white solid Paraffin, which is tasteless and inodorous, and not the liquid article, generally with a repulsive smell, commonly known by that name, which is much used for lamps, and should be called Paraffin Oil.

I have thought it worth while to illustrate the above device by means of a wide-mouthed Bottle containing nothing but Water (×), but serving to show how complete would be the air-tightness, and how good would be the appearance of a glass stopper inserted in hot Paraffin so as to squeeze out a little all round. Another Bottle (×) shows that even an ordinary bung similarly used, would, when cold, become a cleanly as well as a reliable stopper.

By the side of these is a lump of the Paraffin in question (×), to which I shall have more than once occasion to allude. It is sometimes found native in the earth's bituminous strata, and called *Ozokerit* or Fossil Wax, but is generally obtained by the destructive distillation of Bog-head Coal, Peat, and other like substances.*

Canistering, Canning, Tinning.

The processes indiscriminately included under these denominations, vary to some extent in matters of detail, but in all the principle of the exclusion of Air is carried almost to perfection, and the results are proportionately satisfactory. Dr. Letheby, in his Course of Cantor Lectures on Food, delivered at the Society of Arts in 1869, displayed a canister of preserved Mutton, which had been prepared by Messrs. Donkin and Gamble in 1824, and formed part of the stores, which, after the wreck of H.M. exploring ship *Fury*, were deposited in the Arctic Regions, and subsequently brought back to England in a sound condition, though they had for many years been exposed to a winter cold of 92° below zero of Fahrenheit, and a summer heat of 80° above that zero.

Meat, Poultry, Fish, and in short any article of nitrogenous food, alone, or associated with carbonaceous aliments, may thus be durably preserved by a number of patent methods more or less conformable to the following typical description.

As a preliminary, the comestibles are freed from all

* The liquid Paraffin, or Paraffin Oil, is obtained from the same materials in another stage of the process ; it is a lower group of the same series, called the "Paraffin Series," of which the general formula is C_nH_{2n+2}.

that the consumer would prefer not to have. Thus meat is *boned*, an operation performed with remarkable dexterity by the well-trained butchers of the great Australian meat-preserving establishments. The selection and trimming of the parts according to the desired dishes is duly attended to, and all superfluous fat is removed. Complaints are indeed sometimes made that the elimination is too severe, a fact which the well-known tendency of fat to become rancid, if it has the slightest chance, may perhaps serve to excuse.

In Ritchie's process, the Meat is first desiccated, which is said to be done by submitting it to a temperature of 400° or even 420° in suitable ovens, and it is then canistered, adding a little gravy to supply the vapour which you will find presently to be an indispensable element of success. Others fill the Canisters or Cans with parboiled Meat and its liquid accompaniment, whilst others again put into them raw viands and water. A cover which like the whole of the can, must be of substantial and perfectly sound sheet tin, that is to say tinned sheet iron, is soldered on with air-tight precision. It has in the middle a small aperture known as the *Pin-hole*, and which can be instantaneously closed with a single drop of solder.

The *Cooking* is sometimes effected by steam heat, but generally a number of cans, on a perforated tray, are lowered into a saline bath to within an inch or two of their tops. The bath may consist either of brine, with a boiling point of about 229°, or of a solution of Calcium Chloride, which you know is susceptible of being heated to any degree up to 270°. Some firms allow as much as four hours for the operation, beginning at 180° and gradually rising to 230°; others take at once the latter degree reducing the time by one-half. At all events, there is not only abundant, some people think superabundant,

cooking, but heat enough to detach from the Meat any air that may be present, and to drive it out at the pin-hole mixed with a powerful jet of steam.* At last nothing comes forth but steam alone, and the time arrives for the solderer to close the issue with his metallic drop. If the current is too strong, he cleverly stops it by the momentary application of a wet sponge.†

Distinct from the cooking is the *superheating*, which has for its object the thorough extinction of life in all vegetable Sporules, or animal Germs, which may have been brought into the can by the viands themselves, or may have travelled in by air or water. Some persons consider an hour of total immersion in a bath at 230° or 240° as sufficient, but others prefer giving their cans for half that time the benefit of a Calcium Chloride solution at 270°. When we consider that a temperature of 302° so alters the texture of Fibrin as to render it soluble, we naturally conclude that half an hour at 270°, may bring Meat to a somewhat peculiar consistency, which the palate is perhaps too prone to denounce as overdone, whilst the stomach may find it delightfully digestible.

The Cans are now ready to receive their coat of coarse paint, and their more showy outfit of explanatory and characteristic labels ; but before they are launched out into the commercial current, they must satisfactorily stand the six days' ordeal of the Testing Room. This is

* Some patentees accelerate the abstraction of air, and render it more perfect, by the suction of a vacuum chamber.—Messrs. McCall effect the absorption of any remnant of Oxygen by means of a small quantity of Sodium Sulphite ingeniously introduced.

† In some factories, *e.g.* at Aberdeen, soldering is resorted to from the beginning, the obstruction being twice removed and replaced, whereby the driving off of the air is effected with less reduction of the fluid by evaporation—a reduction which, considering the high temperature, must be considerable.

a chamber kept constantly at a warmth favourable to putrid fermentation. They enter it with their flat surfaces *drawn* in by the vacuum resulting from the condensation of the steam which filled their upper portion, or to speak more scientifically, *pushed* in by the pressure of the atmospheric air which is no longer counteracted. If Fermentation takes place, these concave surfaces become convex, being puffed out by the gases resulting therefrom ; and this difference of concavity and convexity is indeed the general criterion for determining the condition of Tinned Provisions. If the cans bulge out, it is best to throw them away at once, rather than to incur by an indiscreet curiosity, a disgust likely to affect the appetite for Tinned Meat, however innocent, for months to come.*

Constant practice with millions of Tins has brought the making and using of them to such perfection, that one seldom hears of any of them produced in noted factories failing to do their duty of air-exclusion, almost the only complaints heard being, that the viands are over-done or insipid. As regards the former defect, it is evident that any means other than long cooking by which the elimination of the air can be secured, as for instance the vacuum process, is deserving of attention, though I would not on any account neglect the superheating required as a safeguard against living germs. As regards insipidity, I may mention that I have sometimes been surprised to find that, though Salt and Pepper are so well known to possess preserving properties, there was not even the moderate amount of each required to satisfy the palate.

* The plan has been tried of introducing Nitrogen or Carbonic Acid to obviate the constant strain of atmospheric pressure, but these expedients do not appear to have been extensively adopted. The use of certain other gases will be adverted to in speaking of Antiseptics.

It is in the judicious and delicate adjustment of Condiments, that lies to a great extent the superiority of French cookery, as compared with the headlong profusion of spices by which many English cooks make manifest the ignorance they think to conceal. There is no reason why the great Australian and other cooked-meat-purveying companies should not send us over ragouts, imitating, if not equalling, those which Englishmen so thoroughly enjoy at Paris.

Preserved Meat that is intended to be eaten cold is generally in Tins of a slightly conical, or rather pyramidal shape, for the convenience of turning out the contents. Specimens of these Tins are displayed (×) together with a selection of cylindrical ones from some of the most noted firms, and also a few of the usual appliances for opening. I may again refer to the wide-mouthed bottle with a glass stopper embedded in white solid Paraffin (×), to which I drew your attention anent the bottling of Fruits. Choice delicacies preserved in this fashion would be more attractive to the fastidious *gourmet* than invisible ones in a canister. The melted Paraffin would be poured in, and the stopper, specially shaped so as not to harbour any bubbles of Air, would be inserted whilst the bottles were in their hot bath.

The tin box which has contained Sardines (×) is intended to remind you that the protection of OIL may be added to that of an air-tight covering. In Italy, whence these little fish chiefly come, they are rapidly cooked by immersion for a couple of minutes in boiling oil, before they are packed in cold oil in these Tins, and the lids soldered down.

Independently of this and other special offsets, so great has been the success of the tinning or canistering process, and so universal its adoption, that most other modern devices for the preservation of Meat have sunk

into the shade. Thus we seldom hear anything of joints kept for an indefinite time by a covering of strong gelatin, or of paraffin, effected by immersion in the melted article ; to say nothing of the more fanciful coatings which have from time to time been recommended, such as Collodion, Caoutchouc, Gutta Percha, or Varnish.

Common Fats and Oils are used for excluding Air to a certain extent as independent agents in Food preservation, but their being liable to rancidity is a serious drawback. Hence it is interesting to take note of the comparative immunity from that defect possessed by the following articles : Taurin, or patent purified beef fat ; an analogous product from sheep tallow ; Stearin ; Cacao Butter ; Oil of Earth-nut (*Arachis hypogæa*) ; and above all Glycerin and Paraffin.

I may also mention among the articles that serve for excluding Air, Sugar, which, in the form of syrup, is often applied in the bottling of whole Fruits. When however the syrup is strong, or when dry sugar is used, it acts as an absorber of moisture, and may be considered as belonging in some measure to the class of agents to which we shall presently pass.

EGGS present a highly putrescible aliment enclosed in a natural shell sufficiently air-tight to preserve it in our climate for a few weeks, but which for long keeping needs additional protection. The chief object is to prevent the absorption of Air consequent on the evaporation of fluid through the pores of the shell ; and this is generally accomplished, in the first place, by a fatty coating, though Spirit Varnish, or Gum, has the advantage of not being subject to rancidity, and Silicate of Soda is sometimes used. Another plan is to immerse the Eggs for five minutes in Water at 140°, or for one minute in boiling water. A second stage of the operation

consists in packing the Eggs, with the small end upwards, in bran dried almost to scorching, lime, ashes, or charcoal powder. Dry saw-dust may also be used, provided it be derived from wood that has no unpleasant smell, for Eggs have a peculiar aptitude for contracting disagreeable flavours.

Preservation by Antiseptics.

The efficacy of these bodies, the Agents of Preservation par excellence, appears to be mainly due to the property they possess of either *abstracting*, or of *indurating* and rendering less susceptible of decay, the delicate *albuminous* constituents in which decomposition is generally initiated to the detriment of their neighbours.

Salt, by far the most ancient, and still the most noted of the Antiseptics, appears to act on the principle of *abstraction.* When packed with Meat in casks, it draws out enough of the albuminous juices to form a quantity of Brine, or if the Meat be at once steeped in Brine, the latter will, according to its strength, still attract to itself a part of the juices, as is proved by the fact that in boiling the resulting liquid, which is necessary in order to be able to use it again, a quantity of coagulated albuminous froth rises to the surface. In order to keep down as much as possible the abstraction of nutritious matter in pickling meat at home, it is usual to allow about twice as much water in the brine as would suffice to dissolve the Salt. The following data are derived from a receipt in Webster's Encyclopædia. Taking 6 or 7 lbs. of Salt to 4 gallons, or 40 lbs. of water, we have a proportion of about 16 per cent. of Salt. To this are generally added about 4 ozs. of Saltpetre,* (×) which besides preserving the red colour

. * The Saltpetre adopted for household use is refined, fused and cast into cakes, and then takes the name of *Sal Prunella.*

of the Meat, adds greatly to the strength of the brine, being reckoned to have about four times the antiseptic power of common Salt.—When salt meat is prepared for commercial purposes and long keeping, the Brine is a saturated solution, containing about 33 per cent. of Salt, and the operation is followed up by packing between layers of Salt.* Now if we consider that, besides Albumen, the juices extracted from the Meat contain the greater part of its Kreatin and other flavouring and stimulant principles, we cannot be surprised at the detriment to health, culminating in Scurvy, which results from a long continued use of "Junk." It is said that Scrofula and certain skin diseases prevalent in some parts of Norway, owe their origin to the use of Salt provisions during their long winters, severe at times, but not so uniformly frosty as to encourage the Canadian method of freezing Meat for winter supply.

The art of preserving Meat, Fish, and the like by SMOKING, whether alone or as a supplement to Salting, was known for ages before Reichenbach isolated the interesting principle Kreasote (×), which gives to wood-smoke its antiseptic properties. So powerful is the action of this body in coagulating Albumen, that the presence of the latter may be thus detected though mixed in 500 parts of water. Attempts have been made to preserve provisions by the direct application of diluted Kreasote, but they should not be encouraged on account of the extremely acrid nature of this agent. Still less is it advisable to use Carbolic Acid, which occupies in coal-smoke a position analogous to that of Kreasote in the smoke from wood, and which, equalling it in antiseptic properties, considerably surpasses it in virulence.

* In Eckart's process mentioned in Spon's Encyclopædia, a pressure of 12 atmospheres is employed for forcing into the meat a solution of Salt and Saltpetre with a little Salicylic Acid.

Notwithstanding the disadvantages presented in a hygienic point of view by the Salting and Smoking of provisions, the one process tending to abstract useful juices, the other to indurate and render indigestible for most persons, their cheapness and convenience still secure to them the preference over the use of laboratory articles, such as Bisulphite of Lime (×), Sulphites, of Potash, Soda (×) or Magnesia, Chloride of Ammonium (×), Chloride of Aluminium (×), Acetate of Ammonia (×), Boro-glyceride (×) and Salicylic Acid (×), though this last was till lately considered a vegetable antiseptic of great promise.* Exposure for 24 or 48 hours to Sulphurous Acid Gas forms an essential feature in several patent processes, the most important of which is that of Prof. Gamgee, in which it is associated with Carbonic Oxide (Carbon monoxide). The vapour of Acetic Acid has also been tried.

The idea of injecting an antiseptic fluid into the circulatory system of slaughtered animals, borrowed from the practice of embalming, does not appear to have met with much encouragement.

PICKLING IN VINEGAR, though occasionally applied to Meat or Fish with a view rather to the enhancing of flavour than to preservation alone, is generally employed with vegetable products, but still Albumen appears to be the chief object of its action. White of Egg, slightly coagulated even by Table Vinegar, which contains about 5 or 6 per cent. of Acetic Acid, is powerfully acted on by Pickling Vinegar, in which you will remember that a greatly increased strength is due to Acetic Acid, derived,

* The French Government has forbidden the preservation of articles of food with Salicylic Acid, which has been proved to be dangerous to health, when used in sufficient quantity to preserve the substance treated with it. A bright prospect seems on the contrary to be opening for Prof. Barff's Boro-glyceride or Glyceryl-borate.

under the name of *Pyroligneous Acid* (×), or Wood Vinegar, from the destructive distillation of Wood, and containing a minute quantity of Kreasote.

The Acetic Acid which flavours Sauer Kraut, may be said to be self-supplied, since it is formed by the fermentation of cabbage leaves, finely cut and packed in casks with Salt. I have seen in Switzerland turnips shredded by an ingenious contrivance, and similarly fermented into a very palatable winter dish. The united antiseptic properties of the Salt put in, and of the Vinegar produced, are often aided by the spicy action of carraway seeds and the like.

ALCOHOL, or SPIRIT OF WINE, besides acting on Albumen by coagulation, appropriates to itself, when strong enough, not only the whole of the moisture, but also the colouring and flavouring constituents of any animal tissues immersed in it, so that its use, as far as they are concerned, is confined to museum specimens, of which the appearance is indeed after a time anything but tempting. Almost the only food article entrusted to it are Cherries, between which and Brandy there is a reciprocal suitableness. The protection of Brandy is appropriately added to that of Sugar before closing pots of fruit, jams, or jellies, to say nothing of the use of Brandy, or strong Wine, for giving a keeping quality to Mincemeat.

The antiseptic action of SPICES is very similar to that of Alcohol as regards Albumen, which ESSENTIAL OILS speedily coagulate.* The stronger of these may also be inimical to parasitical life, and consequently an obstacle to the spread of Destructive Fermentation. Pepper in moderation is a very good adjunct to Salt in sausages and potted meats, and might serve to obviate the insipidity of canistered provisions, but should, on

* The derivatives Thymol and Menthol are medical Antiseptics.

hygienic grounds, never be allowed to mask the high flavour of kept viands, and thus to favour the use of tainted Food.

CHARCOAL POWDER (×) is used with advantage for packing Meat intended to be preserved for a limited time, but its mode of action appears to differ considerably from that of the antiseptics which we have been reviewing: being mainly confined to the immediate absorption of the products of any decomposition that may set in, thereby checking the contagious development of the evil.

Restoration of tainted Food.

I am far from wishing to encourage any laxity of ideas, like that which appears to prevail in China, as to provisions that are not quite so fresh as they should be. The habitual use of them is unquestionably to be deprecated, and on this score, a fastidious palate is a safe one. I have had under my own notice, a case of a troublesome indisposition produced by eating Salmon that was not fresh, at a *table d'hôte* dinner. Nevertheless circumstances may arise in which it may be extremely useful to know that a joint of Meat, too high even for a taste inclined that way, may become an unimpeachable occupant of the dinner table, by being boiled with a few lumps of Charcoal. I remember what was related in that respect by a Professor of Lausanne, who, to obviate the practical difficulty of keeping lumps of charcoal under water, enclosed a number of them in a small net, with a clean pebble heavy enough to overcome their buoyancy, and on an emergency suspended this rustic disinfector, with signal success, from the lid of the *pot au feu.*

C. WHOLESOME AND UNWHOLESOME FOOD.

COMPARATIVE DIGESTIBILITY.*

It is mainly in reviewing seriatim the various articles of Food, that an opportunity will be afforded of ascertaining to what extent their nutritive value is enhanced by their easy Digestibility, or diminished by their being of difficult digestion; but there are certain considerations connected with this important subject which may be best dealt with in a few general remarks. It has already been mentioned that not merely Water alone, but also Water containing substances which, according to Graham's classification, have been termed *Crystalloids*, is susceptible of direct absorption by the capillaries of the Stomach. It appears even by the experiments of Funke † that certain *colloid* Foods may under the action of the Gastric Juice, assume the character of Crystalloids; but with solid aliments, Digestibility, that is to say the faculty of being reduced, by the Gastric Juice and other fluids of the Alimentary Canal, into the condition of a smooth uniform pulp or Chyme, is a necessary condition of assimilation with the Blood, and consequently of Nutritiveness.

In judging of the nutritive value of Food Articles by their proximate composition, which has been shown to afford infinitely more reliable data than ultimate analysis, we must still bear in mind how much even

* For a comprehensive treatment of this subject see "Coombe's Physiology of Digestion."

† See Kirkes' "Physiology."

some of the leading Proximate Constituents are subject to variation in their degree of Digestibility. The following are a few examples :—

Raw Albumen is one of the most digestible of Foods: coagulated, it is comparatively indigestible ; fried, it may become horny.

Fibrin, as presented by some kinds of Meat and Fish, is easy of digestion ; the salted, and especially the smoked, articles afford striking instances of a toughened condition.

Casein in Milk is all that the stomach can desire. In many ordinary cheeses, especially when toasted, it is digestible only to healthy stomachs. Some specimens indeed are the acme of indigestibility, *e.g.* the "Suffolk Bank."

Legumin, the vegetable counterpart of Casein, is not only nutritious, but generally speaking highly digestible ; though it seems that in some cases its fermentative decomposition is even more rapid than the digestive process.

The very slight difference in composition between Gelatin and Chondrin, makes a great one in Digestibility ; but far greater is the change in that respect which supervenes when Gelatin, degenerating into Keratin, takes the almost absolutely indigestible form of Nails and Horn, Hair and Feathers.

Passing from Nitrogenous to Carbonaceous Food, we find Cellulose exhibiting, with scarcely any change of composition, every stage of Digestibility, from the most delicate Parenchyma, to the hard Sclerogen of a peach stone.

You are well aware that material furtherance is given to Digestibility by mechanical division ; and that the most appropriate of all cutting and grinding machines, is the one placed by Nature at our disposal, and which

unites with the process of comminution that of salivation. Your attention has already been drawn to the hygienic importance of a thorough mastication of all aliments in which there is tenacity to overcome. I am not sorry to avail myself of the opportunity of now repeating this piece of advice, which is too often disregarded.

It is one of the privileges of the culinary art to facilitate digestion in cases where the meat is tough, or the stomach is weak. Independently of a discreet use of Condiments intended to stimulate the digestive secretions, the desired result may be accomplished either by a preparatory mincing or other mechanical process, or by making the viands acquire softness in the cooking. The value of this latter expedient is well understood by our continental neighbours, who make tender, savoury, and wholesome dishes, with what among our working classes would be despised. Another expedient is a clever mixture of articles, which, whilst they supply different requirements of the system, as for instance the lean and the fat of Meat, are more digestible together than singly. This rule extends beyond the precincts of the kitchen. The labourer makes a wholesome meal off bread and cheese swallowed in close companionship, whereas if taken separately, the bread would be rather light fare, and the cheese extremely heavy. Similarly, mushrooms, which would agree with the stomach if eaten with bread, would be indigestible by themselves ; almonds are more wholesome eaten with raisins than alone ; and so on with a number of instances, including many of those old established dietetic companionships which are perhaps more numerous and more scrupulously observed in England, than in any other country. Not all, however, are equally founded on hygienic reasons, for there are some that have no better plea in their favour than that they are harmless, and fraught with homely associations.

Much interest was excited in the Physiological world by the publication by Dr. Beaumont, about the year 1834, of his Reports of certain experiments of a most curious and novel nature, which he had been fortunate enough to have an opportunity of making in Canada. It appears that he had the care of an individual named Alexis St. Martin, whose stomach was perforated by a gun-shot wound. The opening healed sufficiently for the restoration of health, but not so as to prevent the introduction of various food-articles, and their sufficient examination at intervals, for determining the relative amounts of time respectively involved in their Digestion. The following are examples :—

Relative Digestibility of certain Food Articles, as shown by the time respectively required for conversion into Chyme.

	Hours.	min.
Boiled Pig's feet. Boiled Tripe. Boiled Rice	1	0
Boiled Salmon Trout. Broiled Venison Steak. Raw Apples	1	30
Boiled Brains. Boiled Sago	1	45
Broiled Ox Liver. Boiled Cod-fish. Boiled Tapioca. Boiled Barley	2	0
Roasted Eggs	2	15
Boiled Turkey	2	25
Roast Goose. Roast Sucking Pig. Broiled Lamb. Boiled Beans. Boiled Parsnips. Roasted Potatoes	2	30
Fricasseed Chicken. Boiled Beef	2	45
Roast Beef. Boiled Mutton. Boiled Apple Dumpling. Indian Corn Cake	3	0
Roast Mutton. Indian Corn Bread. Boiled Carrot	3	15
Raw Cheese. Hard boiled eggs. Fried Eggs. Wheaten Bread. Boiled Potatoes. Boiled Turnips	3	30
Fried Beef. Boiled Fowls. Roast Fowls. Ducks. Boiled Cabbage	4	0
Roast Pork	5	15

Though subsequent experiments made by other observers with the same individual, and analogous ones made with dogs, are said to have corroborated the data of Dr. Beaumont, yet they present striking anomalies which obviously call for explanation; and moreover, even assuming them to be correct, it would be imprudent to adopt them as a base of dietetic regime, without being well versed in the peculiarities, I might almost say in the eccentricities, of our alimentary organs. Without trenching on discussions which must be reserved for the future subject of Dietaries, I may name a few of the circumstances which influence, and of the considerations which relate to, the rapidity and comfort of Digestion.

Appetite must not be confounded with that longing for dainties which becomes habitual through constant indulgence, craves without real want, and makes the replete epicure almost envy the hungry Lazarus. Even a genuine appetite can scarcely be said to be itself a furtherer of Digestion; but it is a sensation, or rather a sum total of sensations, by which the sympathetic nerves make manifest that the system is in want of substantial sustenance, and that the vessels of the stomach are ready laden with the digestive fluid. Among the circumstances which tend to promote, or to hinder a normal manifestation of appetite, and the gastric activity which it calls for, are the following:—Individual constitution and temperament, whether robust or feeble, active or phlegmatic; state of health, whether vigorous, languid or impaired, and in the latter case, nature of the ailment; exercise or rest; placid or disturbed state of mind; dietetic habits, whether given to gastronomic indulgence unrestricted by hygienic rules, or governed by knowledge, thoughtfulness and self-control; distribution of meals, whether extended to four or five in the 24 hours, as now practised by many in England, or restricted to two, as is

frequently the case on the Continent. The promptings of fancy or dislike for this or that article of food, are not altogether to be disregarded, for with adults, as well as with children, and especially with sick persons, there may sometimes be an instinctive indication as to what under the circumstances may be beneficial or injurious through easy or difficult assimilation; but their promptings should not be implicitly followed, for they may otherwise prove to be the germs of prejudicial habits difficult to conquer. The effect of salt, pepper, mustard and other stimulant condiments, in accelerating the digestive process, and of certain other articles in retarding it, will be duly discussed in treating of those Food Adjuncts, and I will only add to the already long list of the circumstances to be taken into account in seeking to establish practical standards of digestibility, that to a certain extent variety of fare promotes Digestion, and even variety in the mode of cooking one and the same article.

It has been proved, by evidence sadly conclusive, that the unbroken continuance of a diet which might be thought free from reproach, may be productive of maladies such as would only be expected from a slow but deadly poison. I have often pitied the Lombard Peasantry, confined to their monotonous Maize Porridge or *Polenta*, cooked in the most primitive fashion, with scarcely an attempt to emerge from uniformity, and rather calculated to stifle the appetite than to satisfy it; but at all events I thought the meal was as wholesome as it seemed nutritious, and little imagined that even this innocent aliment would be found injurious through its very simplicity, and insidiously lead those hard-working frugal *contadini* to the woe-begone condition described in the following extract from an article in a daily paper, headed "The *Pellagra* in Italy."—"It is about 150 years since the pellagra made its appearance in Europe, first in Spain,

afterwards in France and Italy, and later in Greece and other countries. In Italy the scourge has assumed vast proportions. In the province of Bergamo alone, in the year 1878, at least 20,000 persons, it is calculated, were afflicted with the terrible epidemic, almost 10 per cent. of the agricultural population of that province. The effect of the malady is a complete degradation of the physical and intellectual powers. The greater part of the victims either die in lunatic asylums and hospitals, or commit suicide, leaving the seeds of the malady (a sad heritage) to their children. This is a terrible picture, and Signor Alborghetti, a member of the Provincial Commission of Bergamo, from whose report, lately published, I gather the above particulars, advocates the most urgent and stringent measures on the part of the Government to arrest the ravages of the disease. It has been incontestably proved that the pellagra made its appearance, and increased with the increased cultivation of maize, and that whatever the difference of soil, climate, race, social regulations, manners and customs, those places only are infected where the food of the agricultural population consists chiefly in maize flour in the shape of polenta or bread, and that even those already affected with the malady are speedily cured if their diet be varied with meat, vegetables, &c."

NOXIOUS FOOD.

Though by far the greater part of the remarks which this subject suggests relate to Animal Food, they will be better placed here, and find more congenial surroundings, than if they were deferred to the review of the Food supplied by the Animal Kingdom. We will take them in the following order:—

Animals of which the flesh is occasionally or constantly injurious.

Animals of which the flesh becomes injurious under special circumstances.

Animals of which the flesh is rendered unwholesome by disease.

Animals of which the flesh is rendered dangerous by parasites.

Tainted Animal food.

Unwholesome Vegetable Food.

It has been seen that differences of constitution and temperament are among the causes which may influence the time required for digesting a given article of Food. Their influence is so powerful that articles digested with ease by some persons, disagree most decidedly with others, without any abnormal condition of the stomach being apparently the cause of the mischief.

That the flesh of the Pig should sometimes cause Diarrhœa is not perhaps much to be wondered at, considering with what foul garbage that animal is often fed. That a similar result should occasionally be produced by Lobsters, and especially by Crabs, is still less surprising.

Shell-fish eaten by some produce Dyspepsia and Nettle-rash. Mussels and the like are as a rule poisonous in the breeding season, and the worst is that the subject is full of anomalies, so that even Oysters cannot always be eaten with impunity, though fresh and *in season*. The time of year may possibly be accountable for the harm done by certain Fishes, such as the little herring and the pilchard.

Pappenheim enumerates more than 40 species of fish

which are occasionally poisonous, and some of those found in the tropical seas manifest an extraordinary degree of virulence. It is said that eaters of the yellow-billed sprat have been known to expire before they could swallow their mouthful; and two sailors who had been warned not to eat a Bladder-fish, about 6 or 8 inches long, but thought they could safely venture to partake of its liver, weighing perhaps half an ounce, were both dead in 20 minutes.

The flesh of animals that have come to a sudden death through accidents is not injurious on that account, though it is hurtful in cases of prolonged suffering or wild terror. It is known that the flesh of hunted hares will not keep long, and Liebig, in his Letters on Chemistry, relates that five persons were made seriously ill by the flesh of a roebuck, which had been caught in a snare, and had struggled violently before death. This renders perfectly credible the assertion that a skin complaint is occasioned by the flesh of cattle that have been over driven.

It has been noticed that certain plants render poisonous the flesh of beasts that feed on them without appearing to affect the health of the animals themselves. Dr. Letheby attributes to a similar cause serious mischief from eating prairie birds imported to this country.

A question of great importance, concerning which a deplorable uncertainty prevails, is the mischief to be apprehended from the use of DISEASED MEAT, an article affirmed by competent authorities to be consumed to a much greater extent than is commonly supposed, and to be the cause of many cases of illness not otherwise accounted for.* Of course much depends on the nature

* Prof. Gamgee says that one-fifth of the meat in London is more or less diseased.

of the disease, and sometimes extraordinary instances occur of immunity from harm where the worst consequences might have been apprehended, but the cases of undoubted mischief are quite sufficiently serious to justify the most searching investigations with a view:—*firstly*, to draw practical lines of distinction between what is dangerous, and what is merely disagreeable to think of; *secondly*, to determine the diagnosis of the various diseased meats; and *thirdly*, to point out remedial measures as far as they may be available.—Butchers ought at the same time to be taught how to recognize the Antimony with which they complain that the animals sold to them have been physicked.

FLESH PARASITES. Allusion has already been made to the garbage with which Swine are too often fed, and to the injurious quality sometimes thereby imparted to their meat. To the same cause is ascribed the fact that the flesh of these animals is occasionally infested with Parasites, which are as dangerous as they are disgusting, for if they are given a chance, they make themselves equally at home in the sinews of the human body, thus adding a new sense to the word *amphibious*.

Extraordinary as it may seem considering the early progress of microscopic research, it was not till the year 1860, that the occurrence of fatal cases in Germany, led to the discovery that a certain minute worm, established in the muscular fibre of the Pig, keeps on feasting there till its full growth of about one-thirtieth of an inch is attained, and its voracity satiated. It then coils itself in the spiral form which has won for it the name of Trichina *spiralis* (×), and envelopes itself in a cocoon-like cell called a *cystus* or *cyst*, and mainly composed of Carbonate of Lime.

It appears that other animals are troubled with the Trichina complaint, or Trichinosis, including Birds, Frogs and Rats. These last in particular are said to be much infested with them, and some persons think that omnivorous Swine get them from this ignoble source. If Pork containing a number of these apparently harmless specks be eaten raw, as is frequently the practice in Germany with regard to hams, or if in the form of joint or sausage it be imperfectly cooked, the calcareous shell, being soon dissolved by the Gastric Juice of the unfortunate consumer, the little worm awakens to a new life in the Intestinal Canal, unfolds its spiral, seeks companions of its kind, and through a prolificness amounting to as many as 500 at a birth, a multitude of young settlers is produced in a few days, which starting in various directions, grub their way to the muscles that best suit them. If the wretched sufferer who affords them involuntary hospitality has sufficient strength of constitution to endure the long ordeal of their full development, they release him from his torture by falling asleep in the charmed calcareous receptacle, which this time no Gastric Juice is likely to dissolve.

In the free state the Trichina is not easily discernible, but its rounded capsules are easily detected with the aid of any ordinary microscope, and sometimes by the naked eye. The unprotected worm is certainly killed by submitting the meat infested with it to a heat of about 150°, whereas when it is encapsuled, you should not trust to any heat less than that of boiling water ; nor should this temperature be of short duration, and merely superficial, as is too often the case in cooking joints of Pork. Frequently the interior of a large piece of boiled or roasted Meat does not reach beyond 150°, and if a raw-looking redness remains anywhere, that part may be assumed scarcely to have gone beyond 130°. Where the

danger is so frightful, it is well to make safety doubly sure, and remembering the guarantee from zymotic germs afforded to canistered provisions through submitting them to a temperature of 270°, one asks oneself whether it might not be advisable to adopt the plan of cooking suspicious viands, either by means of steam from a saturated solution of Chloride of Calcium, or better still, in digesters with appropriate safety valves, standing in a bath of the said solution kept up to its boiling point.

Even if the awful Trichina did not exist, there would still be sufficient cause for caution in using the flesh of Swine. It had long been suspected that the Tape-worm (*Tænia solium*) (×) which attains to such enormous length in the human intestinal canal, reaching sometimes to 18 or 20 feet, and slowly undermining the constitution, was in some mysterious manner connected with a small thread-like parasite found occasionally in the flesh of the Pig, and called *Cysticercus.* It was however reserved for modern investigation to ascertain that this thread-like worm, ending in a bladder-like expansion, is in reality the first stage of development of the Tape-worm. It nestles in a capsule much softer than that of the Trichina, but at the same time much larger, so as to be easily detected by the naked eye, having the appearance indicated by our drawing of a piece of so-called "Measled Pork" (×). The name is rather a misleading one, for Swine affected with these internal parasites have nothing to do with real measles; but it may be a useful title if it strikes terror and induces caution.

Similar members of the tribe of Entozoa, or *livers within*, are found in Beef and Veal, but they are far less frequent than those of the Pig, and smaller. I will conclude this not very inviting subject, with a quotation from Dr. Pavy's work on Food.

" Other parasites are encountered in the visceral organs of animals, but the Cysticerci (Tape-worms) and Trichinæ are the only ones, as far as is known, of a hurtful nature in an alimentary point of view, that infest their *flesh.*"

TAINTED FOOD. It is unnecessary to follow into all its details the shadowy side of the subject of Food, but it would be too incomplete without a formal notice of a class of dangers to which a passing allusion has more than once been made; namely, those incurred by eating Provisions in a state of incipient decomposition. Most unfortunately, opinions and even facts are conflicting, and the question is still further embroiled by the extraordinary habits and fancies indulged in, not only among nations whose semi-civilization abounds in eccentricities, but even among our own epicures, whose example is more dangerous. We are not likely to be fascinated by the example of the Siamese, who are said to make a favorite condiment with rotten Fish, or by that of the Chinese, who keep Eggs till the white is set, and the yolk is green, and the smell is equal to Harrogate Water multiplied by itself; but we are apt to become bewildered when a sage of the calibre of Liebig, says that at the end of a feast, a little game, or venison, or ripe cheese, with just a piquant touch of decay, may promote digestion by communicating its own quality of transformation to the rest of the food. Remembering how great is the difference between *solution* by the Gastric Juice, and *decomposition* by an incipient putrid fermentation, a difference marked by the evolution of fœtid gases, and of which we have occasionally a reminder when Green Peas decompose more quickly than they can be digested, we are half inclined to see in the remark of the great German Philosopher, a sophistical defence of a

fashionable foible. We are supported in this idea by Dr. Letheby's assertion that "game when only sufficiently tainted to please the palate of the epicure, has caused severe diarrhœa in persons unaccustomed to it. . . As a rule there is a natural abhorrence of tainted food, insomuch that with most persons the mere commencement of decay is sufficient to excite disgust."

I purposely abstain from relating to you the more sensational of the arguments on either side of the controversy, the frightful instances of suffering and death occasioned by eating animal food in an advanced stage of decomposition, or the less sad, but perhaps more disgusting cases of immunity. I think you will prefer my summing up as impartially as I can to the following effect:—

> We should encourage rather than combat the sensitiveness of the olfactory organs, which are probably as correct in repelling us, as they are in attracting a vulture.
>
> Special caution should be observed in abstaining from tainted food when Cholera, Typhoid Fever, and other zymotic diseases are rife.
>
> If at any time stern fatality should necessitate our making the best of tainted provisions, we should not neglect the two palliatives which have been found most effective:—1stly, boiling with charcoal, and 2ndly, toasting, grilling, or frying, so as to thoroughly expel the volatile products of decay, and to check their further production. A strong seasoning should also be resorted to in order to mitigate as much as possible the repugnance of the stomach.

The most poisonous changes in the constitution of Meat are not always those announced by the most

repulsive odour. There is a kind of modified putrefaction which produces what is called the *Sausage Poison,* from the frequency of its occurrence in certain German Sausages, and especially those of Wurtemberg. Analogous effects have however been produced by other kinds of animal food, such as ham, bacon, salt-beef and salt-fish, especially it would seem, when heaped together in large quantities. I well remember the sensation created in Switzerland in 1839 by the disastrous effects which resulted from partaking of a number of hams which had been piled up in a cellar, in preparation for a festive gathering at Zurich, and were found on investigation to exhibit an incipient decomposition, and a slight mouldiness. Possibly that peculiar form of fermentation had set in to which is ascribed the production of those virulent alkaloids already adverted to under the name of *Ptomaïnes.* Possibly on the other hand, Prof. Corput may be right in attributing this disaster to a species of Fungus which he names *Sarcina Cotulina.* He ascribes to a similar cause the no less fatal consequences produced by spoiled Cheese, respecting which Letheby mentions as many as five localities in Germany where official enquiries had been instituted to discover the real nature of the constantly recurring disasters.—Our ignorance respecting the whole subject of tainted and mouldy provisions, is however such, that the safest hypotheses are those which most emphatically proclaim caution.

There is, it is said, no rule without exception, and I can speak from experience of a notable one to the rule that the fermentation of nitrogenous food is always hurtful. That exception is afforded by the Sour Milk, which eaten with sugar and a little ground cinnamon, forms in Germany during the summer time, so favorite an article of refreshment.

UNWHOLESOME VEGETABLE FOOD.

We here find in a hygienic point of view, less scope for general remarks than in Animal Food. Setting aside the great alcoholic difficulty, which will be reserved for the subject of Beverages, you will not as you thread your way through the successive groups of Vegetable Products, come across so many perplexing controversies as in the region of which we have been making a preliminary survey, or encounter so many of those dangers which are the more to be apprehended because they are little understood. Ignorance and prejudice will seem to be less thick, and popular notions will not so much require correction. At the same time you will find that there are many points on which you will be able to bring to bear the advice I have been giving you.

INDIGESTIBILITY will in some instances be found to attach more or less to whole series, as for instance to the Kernel Fruits, such as Filberts, Almonds, Cocoa-nuts and the like. In other cases the facility or difficulty of digestion will very much depend on individual temperament, as for instance with Melons, which some persons can indulge in freely, whilst others must partake of them with the greatest caution.

SEASON does not affect vegetable products in the same way as it does animal ones ; yet it must be remembered that unripe fruit is a cause of frequent mischief, especially among children, and should be particularly shunned when Cholera, or indeed any form of enteric disease, is prevalent.

NOXIOUS PLANTS. Various plants which tempt the ignorant into suffering, and sometimes with fatal results, have been the subject of pictorial illustrations, for which

the Programme of the Museum indicates a place in the Section devoted to "Personal Safety."

PARASITES. The disastrous Potato Disease which has been alluded to in connection with the drying oven for mitigating its consequences, reminds us that Parasites are not confined to the Animal Kingdom, for it is occasioned by a mischievous fungus termed the *Botrytis infestans.* I must also mention the dangerous nature of the peculiar fungus called *Ergot*, commonly known as "Ergot of Rye," because it seems to have a predilection for that grain, though it also occurs on Wheat, Barley, Oats, Maize, Rice and other grasses. A representation of the manner in which its black spurs protrude from the ears which they infest, is reserved for the review of the Cereals, and I need now only mention that frightful consequences have at times been known to result from its prevalence, though at the same time it is, when cautiously administered by medical practitioners, of undoubted service in certain difficult cases of midwifery. —The Rusts and Blights of Corn (various species of *Uredo*) and the Mildew of Wheat (*Puccinia graminis*) will also be spoken of in connection with the Cereals. The Darnel (*Lolium temulentum*) will likewise find its due place in treating of the Grains with which it mixes its poisonous seeds.

INCIPIENT DECOMPOSITION does not present in Vegetable Food, nearly so repulsive an aspect, nor so forbidding an odour, as in Animal Food, and one is less surprised to find that opinions differ as to where the threshold of rottenness lies. It is a very innocent stage of decay that makes a Medlar ripe, and certain Pears sleepy ; but as a rule it is best to consider as unwholesome, all changes in the consistency of Fruits or Vegetables that are produced by injury or too long keeping. Provisions of which the deterioration is marked by the

presence of the various species of Mucor, Botrytis and the like, collectively known as *Mould*, should be avoided, or exposed by baking, toasting or otherwise, to such a heat as to drive away volatile products, and destroy live ones. As regards Mites, Acari, and Weevils, they are considered harmless, which without being an inducement to eat them, should be a consolation to those who cannot help it.

D. ADULTERATIONS OF FOOD.

Not the least interesting among the subjects ably canvassed by Dr. Letheby in his Cantor Lectures on Food, is that of ADULTERATIONS or SOPHISTICATIONS, and here as elsewhere, the sound practical judgment of the late Officer of Health for the City of London, points to the true rational medium to be maintained between the apathy which prevailed on this score in times of total ignorance, and the outburst of indiscriminate suspicion and violent censure which succeeded, when, about 1820, Accum directed the bull's-eye of his chemical lanthorn towards this new field of startling revelations. It is in a sober and practical spirit that all ordinary sophistications will be discussed in the methodical review intended to form Part II. of the present work. The abundant illustrations of adulteration and fraud there described, will be the better understood for being in juxtaposition with genuine articles, so that a display of duplicates in the present section has been deemed inexpedient. In the mean time it may not be amiss that we should prepare ourselves for that discussion by a few general considerations, taking particular note of the greatly varying aspects in which the several cases of adul-

teration and fraud present themselves when considered from a social and moral point of view.

First of all we may separate from Adulterations proper, or rather I should say, from improper Adulterations, those Admixtures which are necessary for giving to an article the properties for which it is intended. For instance, powdered Mustard requires for being mixed intimately with Water, about 10 per cent. of Flour, which serves also to temper to the right degree its excessive pungency. So far the admixture is a legitimate one, and no adulteration, though it might be considered as such by ignorant persons. Beyond 10 per cent., the admixture of flour would begin to be fraudulent, and consequently to be an *adulteration.* Vinegar affords an example of an analogous character in a contrary direction. When you ask for Pickling Vinegar, you must be glad to have an article sharpened with Pyroligneous Acid, which is not only vastly stronger than the Vinegar from Wine or Malt, but has for preserving purposes, the advantage of containing a minute quantity of Kreasote. Here, supposing the price to be correct, there would be no adulteration. On the contrary a mere dilution of Pyroligneous Acid would lack the proper flavor, and be fraudulent. As for the use of Sulphuric Acid, though allowed by law to the extent of 1 per cent., with a view to prevent the Vinegar from "*mothering*," or becoming mouldy, it should certainly not be indulged in beyond that limit.

Having set aside legitimate admixtures, we shall still find among those which are decidedly not for the benefit of the customer, many distinct degrees of culpability. Thus the adulteration of true *Maranta* or West Indian Arrow-root with cheaper Arrow-roots, which produce a rather less refined pudding, but are almost if not quite as nutritious, would be a small offence, if the price were lowered accordingly, but would be a culpable fraud if it

were not.—To dilute Milk with Water, be it ever so pure, is an evident misdemeanour ; to make up with Whiting, as said to have been formerly the case, was worse.—To grind Beans with Wheat is in some cases a pardonable expedient ; to mix Alum in the Flour is very wrong ; to substitute Copper Sulphate is atrocious.—To make Beer bitter with Quassia instead of Hops, is bad enough ; to use Cocculus Indicus for producing a form of intoxication more closely allied to madness, is simply horrible.

ADULTERATIONS are sometimes separated into three divisions, according as their purpose is :—

1. To increase the bulk or weight of the article.
2. To improve its appearance.
3. To give it a false strength.

Some difficulty however presents itself in attempting to carry out this arrangement, inasmuch as the adulterations practised with a single article often belong to more than one division, and sometimes to all three. Thus Tea may be sophisticated by adding leaves, which after doing duty have been dried again, and serve to increase bulk and weight ; or Prussian Blue may be used, as it occasionally is, to improve appearance, courting the customer's eye at the expense of his health ; or again a small quantity of Green Tea may be mixed with the black to strengthen its flavor.

Again the support given to Coffee by Chicory is of a character not easily defined. In considerable quantity, and not avowed, it is unquestionably an adulterant. In moderation, it adds tonic qualities, and color. In a proportion of about an ounce to the pound, it is thought by many persons to improve the flavor, and might be favorably considered by many more, had it never been made an instrument of deceit.

Sugar is much less tampered with than in former times, owing to the remarkably low price at which it is now

brought into the market. One now seldom hears of its adulteration with Glucose prepared by chemical means from Potatoes and other starchy substances, and possessing an inferior sweetening power. As for Beet Sugar, the progress of the art of refining has so satisfactorily assimilated it to Cane Sugar in quality as well as in appearance, that its admixture can scarcely be considered a deterioration.

Butter is one of the articles on the sophistication of which the greatest amount of chemical ingenuity has been bestowed, and the selection and preparation of adjuncts or substitutes has mostly been so clever, that there would be little fault to find if all were carried on with careful discrimination, and open-handed sincerity.—In support of this, I may be allowed to quote the following from the "Daily News" of June 13th, 1881.—"Mr. Archibald, British Consul at New York, considers the manufacture of Oleo-margarine to be legitimate, when properly conducted. When extracted from pure beef fat, the product is closely allied to sweet dairy Butter in every essential quality. The shipments are mostly to Holland, the Dutch excelling in the art of manufacturing it into *Butterine*, and possessing already 100 factories, with a business rapidly increasing. Good Butterine is considered by Mr. Archibald to be much better than bad Butter."

Details like these show forcibly the influence of increased facilities of transport, in extending the resources of fraudulent enterprise, no less than those of genuine supply. At the same time the publicity given to information like this through the daily Press, affords an excellent guarantee that counterfeit articles will have little chance of durable success on a large scale, unless they approach in merit to genuine ones. In fact the public has become alive to the requirements of the

situation. In every department of consumption, the weapons of defence have been perfected quite as much as those of attack, and the fair-play-loving community has over its aggressors, who are jealous rivals of each other, the great advantage of a regular strategic organization. In other words, the good work initiated by literary disclosures has been followed up by the appointment of Officers of Health and Public Analysts, on whose well trained eye and zealous exertions we may reckon for keeping down, if not for extirpating, the rank weeds of commercial avarice.

E. CULINARY PROCESSES.

RATIONALE.

To the question,—What is the real use of Cooking ?—no scientific explanation can perhaps afford so conclusive an answer as does a practical demonstration. As regards Vegetables, bite successively into a raw and a cooked potato. The change will speak for itself. Then as regards Meat, set likewise aside for a few minutes those feelings of disgust which some people affirm to be but the conventional effects of routine and prejudice, and try to chew a piece of raw beef-steak. Its flabby toughness baffles the incisive bite and the molar grinding ; but apply the proper culinary resources, and it will stand up and resist the teeth just sufficiently to be conquered, and they will cut and masticate it satisfactorily.

It is useful as well as interesting to enquire into the "Reason why" of changes like these.—As for the Potato, the essential point is the bursting of the Starch cells. As regards the Meat, it will be well worth while to examine the behaviour under culinary treatment of the

several Primary Constituents of Flesh, which we will take seriatim in the order in which they were previously studied. We will afterwards consider a few salient features of the chief Culinary Processes.

Action of Heat on the Proximate Constituents of Meat.

ALBUMEN is the constituent of which the altered consistency contributes most to the change effected by cooking in the condition of Meat; for its coagulation tends materially to afford to the shreds of the Fibrin with which it is intermixed, the support required for their mastication.* This coagulation is also taken advantage of by the cook for making the outer portions of a joint serve as a barrier to keep in the juices of the inner portion. It is with this view that in roasting a joint of which one wishes to keep the inside in a juicy and sapid condition, it is exposed at first to a violent heat. When the Albumen of the outside is set, the process may be continued at a more moderate temperature. Similarly, if a joint is to be boiled irrespectively of Soup, the Water is raised to 212° to receive it, and after a time when the barrier of coagulated Albumen is deemed sufficient to prevent the juices getting out, or the water getting in, a mere gentle simmering is kept up. Liebig gave 170° as a sufficient continuous heat in

* According to Parkes ("Practical Hygiene," p. 219), a notable difference exists in the temperature required for coagulation by the several varieties of Albumen. One variety coagulates at as low a heat as 86°, if the muscle-serum be very acid; another at 113°; the hæmatoglobulin coagulates at 158° to 162°, below which temperature the Meat will be underdone. A large quantity of Albumen coagulates at 167°.

roasting or boiling, and we shall even see presently that serious objections are raised by some authors against higher temperatures; but on the other hand, we are wisely reminded by Liebig and others, that one of the most important objects in cooking is to destroy all parasitic and zymotic life, and that for this purpose the temperature of Boiling Water should be reached, and retained for a reasonable time by all portions of a joint inside as well as out.

FIBRIN, the most important of the Proximate Constituents of Meat, forming as it does the main substance of the Muscular Fibre, seems nevertheless to have been but imperfectly studied in its bearings under the action of Heat. Parkes and Pavy agree in stating that above 170°, muscular tissue manifests a tendency to become hard and indigestible, an assertion which may be accepted with satisfaction by the partisans of underdone Meat, but which, if there were no escape from it, would stand awkwardly in the way of that hot extermination of germs and parasites, which we have seen to be often a matter of such urgent importance. Fortunately, every *chef de cuisine* can give practical proof that Meat of good quality may be served up thoroughly well done, and yet perfectly tender.

One might be inclined to lay the blame of any induration of the kind in question, to the Albumen, owing to its tendency already mentioned of acquiring under increased or prolonged heat, progressive degrees of toughness, far exceeding that of a mere gentle coagulation. At all events the unfavorable change attributed to Fibrin between 170° and 212°, would not affect the fact of its becoming soluble at 302°, and the probability that before reaching that heat, say at 270° (the temperature attained in the super-heating of canistered provisions) an incipient tendency to disintegration may set in. This

would be valuable if careful investigations were to prove that it could be applied to certain coarse joints, which are not fit for roasting, and of which the fibres when released by dint of boiling from the Gelatin which held them together, are stringy and uninviting. So much is this the case that coarse tendinous pieces are only used for yielding stock. Fibrin is too nutritious to be wasted, and when culinary action fails to make it tender, mechanical devices should be resorted to, as in making potted meats. Not only is it decidedly wrong in the point of view of nutrition to remove the floating particles of Fibrin, as is often done for the purpose of making what is called "Clear Soup," but excellent results may be obtained by thickening Broth for invalids and others with cooked Fibrin finely chopped, and pounded or ground to a paste.

CASEIN, except in Milk, is not as a rule subjected to culinary treatment. Its indigestibility to most stomachs when toasted has been already alluded to.

GELATIN as might be expected exhibits under culinary treatment, a behaviour inverse in some measure to that of Albumen. In roasting, a portion of it dissolves in the juices of the Meat, forming a rich gravy which partly exudes and is collected in the dripping-pan, and partly waits to make its exit at the carving of the joint. A large portion ought to remain in the meat to maintain its succulency whilst hot, and when cold to *set* into a stiff jelly. This constitutes a new support to the Fibrin, and accounts for the facility with which a cold joint may be cut in all directions almost as if it were cheese. In boiling, something similar occurs if the Soup is sacrificed to the Meat, and Water at 212° is begun with. If on the contrary, the Broth is a main consideration, and consequently the temperature of the Water is *gradually* raised, the Gelatin of the connective tissue which per-

meates the muscular fibre, and ensheaths its bundles and bundlets, is by degrees dissolved away, and at last the piece exhibits a ragged congeries of shreds of Fibrin.

FAT, especially that substantial portion known as Suet, is, as a rule, traversed in all directions by fibres of connective tissue, or it may indeed be said to be stored up in the meshes of an irregular network of that material, which is mostly, but not entirely gelatinous. When a joint is *boiled*, much of the Fat melts and rises to the surface, where any excess is skimmed off. Or when the Broth has got cold, it forms a solid cake at the surface, and can with ease be much more completely removed. When a joint is *roasted*, a portion of the outer Fat melts and drops into the dripping-pan, another portion remaining exposed to the full heat of the fire on a spongy exuvium of collapsed tissue, becomes sometimes decomposed, giving rise to the product called Acrolein, already described (page 35), mixed with certain fatty acids ; the whole more or less acrid, and likely to disagree with delicate digestions. I shall have again occasion to revert to these noxious fat products in speaking of frying and broiling, which are particularly apt to favor their formation.

As regards THE ACCESSORY ORGANIC PRINCIPLES, you will remember my mentioning under that head Kreatin and its kinsman Kreatinin, two substances of an alkaline tendency, which although occurring in very small quantities, are considered as increasing notably the nutritive qualities of Meat, in the juices of which they are dissolved. Other inconspicuous nitrogenous compounds, among which the most important appears to be Inosic Acid, act with them as taste improvers. The last mentioned appears to be specially concerned in emitting the perfume which so delightfully tickles the appetite when a roasting joint reaches its maturity. All

of these bodies may more or less be considered as contributing, when first concentrated, and then partially decomposed by a sharp and persistent heat, to the formation of that mysterious Osmazome, of which no chemist appears to have yet determined the exact composition, though from time immemorial the eyes of epicures have gloated on its rich gradations of golden brown.

With the foregoing Nitrogenous Meat-improvers, are found a few Inorganic Salts, such as Phosphates of Potassa, Magnesia and Lime, and Chloride of Sodium which dissolved in the juices of the Meat, gives a piquant flavor in proportion as these juices become concentrated by heat.

PROCESSES.

Passing to the consideration of the actual CULINARY PROCESSES, we notice that they mainly divide themselves into two categories, the *wet* processes headed by Boiling, and the *dry* processes, among which Roasting takes the lead.

As a preliminary to the former group, I may mention an extremely simple operation, which might almost be called "Cooking without fire."—If you allow finely chopped lean of Beef to soak in cold water with a few drops of Hydrochloric Acid and a small quantity of Common Salt, BEEF LIQUOR will be obtained, containing the whole of the meat juices, including the liquid Albumen. This strengthening draught for weak stomachs may be taken cold, or if preferred, it may be raised as high as 100°, but above that temperature the Albumen would begin to coagulate. Frequently however the chopped meat is left in, and a heat of 212° is purposely applied, the whole of the Albumen rising to the surface in a frothy consistency is removed, and the hot beverage takes the name of BEEF TEA. This again reduced by evaporation to the consistency of a thick syrup, yields genuine Liebig's EXTRACT OF MEAT, but much of the article sold under that name consists partly of Gelatin, which has become dissolved through leaving the chopped meat too long in the boiling broth.

It is rather curious to see how many considerations arise out of these simple processes :—

1° As regards the liquid Albumen contained in the cold Beef Liquor, its nutritive value surpasses that of any other constituent, and its elimination from the Beef Tea is regrettable.

2° Some persons are apt to attach to Beef Tea and Liebig's Extract, an exaggerated notion of nutritiveness.

From the fact that over 30 lbs. of muscular fibre are required for producing a pound of Extract, they arrive at a vague idea that half an ounce of the latter will afford a substantial meal ; nay, that being the outcome of a pound of meat, it will by a kind of magic, which they imagine Chemistry to be perfectly capable of, produce in its turn a pound of living flesh. They forget that the waste of our flesh and blood can only be made good by an equivalent assimilation of actual materials. Quality alone cannot make up for quantity.

3° Certain Chemists zealous in a contrary direction, look upon the products which Beef Extract derives from the juices of the meat, as merely so many *flavorers*, which may conveniently serve to deceive the palate. Some go even so far as to regard Kreatin and Kreatinin, like the Lactic and Butyric Acids found in their company, as so many effete and excrementitious substances, similar in some measure to Urea. This opinion may possibly derive support from the fact that the meat juices mainly consist of the Serum of the Blood, itself the vehicle of much effete matter, united with the serous fluid of the Lymphatic System, of which the contents are still more suspicious.*

* The Lymphatic vessels collect for being conveyed back to the Blood, the Serum which after oozing from the Capillaries with a load of useful materials, has delivered these to the Tissues, and has received in return the results of the splitting up of the Albuminoids, viz. on the one hand, Carbonic Acid and Water produced by the oxidation of the resulting Carbo-hydrates, and on the other hand Urea, with other products of analogous descent. The idea that the Kreatin family are of this ignoble lineage is not a new one. Carpenter in his "Principles of Physiology" mentions researches tending in this direction. Kirkes says ("Handbook of Physiology") that Kreatin and Kreatinin are "no doubt products of the chemical changes that take place in the natural waste and degeneration of the tissues, and are substances that are to be separated from the tissues for excretion." Pavy speaking of the extractive principles

4° It is difficult to reconcile views like these with the accounts of the benefits derived from Liebig's Extract, which not only pass current among its thousands of unscientific admirers, but have obtained the sanction of eminent practitioners and savants. The safest course may be to assume that Kreatin, Kreatinin, and Inosic Acid, have on our system a stimulant action somewhat analogous to that of Theine. They may render more prompt and more efficacious the assimilation of any wholesome food with which they may be associated, and they may even give so effective a fillip to an exhausted system, as to enable it to dispense for a time with real Food ; but it is clear that we must not look to them for direct nutrition.

5° Another question which arises in connection with this Extract, is that of the amount of detriment involved by its frequent adulteration with Gelatin. The latter being vastly cheaper than the Extract itself, and its presence not avowed, it is if introduced in any notable proportion, unquestionably a fraudulent adulteration. The extent of the injury inflicted on the purchaser would be great indeed, if all things were incontestable that are said of the Extract by its friends, and of Gelatin by its enemies ; but merits and demerits must alike be taken *cum grano salis.*

I may conclude this topic by saying that I am not disposed to under-rate any good results shown by experience to be derivable from the use of Meat Extract, but still less am I inclined to look upon Gelatin as a valueless flatterer of the palate and the eye, or to consider as mere ephemeral freaks of culinary fashion, the

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of Meat, suspects them of being "products in a state of retrograde metamorphosis, and of no use as nutritive agents." Lastly, according to Kingzett ("Animal Chemistry") that Kreatin "is an excretory product, there can be little doubt."

Broths and Jellies which perpetuate the dietetic instinct of our forefathers. Letheby was surely not unjustified in saying that SOUP may be made so nutritious as to take the place of solid Food, and in upholding the value of that most economical of culinary devices, the savory *pot-au-feu.* Few persons, especially among those who have travelled on the Continent, are likely to question the benefit which the British Working Man might derive from this humble resource of his neighbours, provided he bestowed on it the thoughtful care with which they make it as thrifty as it is palatable and wholesome. At all events I need not rake up the Gelatin controversy* in selecting the earthenware *Marmite* as a representative type of the Boiling Process, and inviting you to inspect one in the Department of the Museum (Class III.) devoted to Household Furniture and contrivances that have a hygienic bearing.

Near it is one of those ingenious appliances frequently but improperly called "*Norwegian Cooking Stoves.*" They are not stoves at all, and are indeed contrived to supersede to a great extent the use of stoves. As soon as the pot or kettle in which the Workman's dinner is being cooked has been a short time at the boiling point, it is removed to one of these Boxes lined with a thick layer of felt, which from its non-conducting nature keeps the contents for several hours at the temperature sufficient to turn out meat and vegetables thoroughly done. It is well to know that on an emergency an apparatus almost as serviceable may be improvised with hay in lieu of felt.

I trust you remember what was said of the WATER-BATH in treating of the action of Heat on Water; how the rising temperature of the latter is checked at 212° by ebullition, that is to say by the giving off of vapor equally possessing that temperature, so that an inner

* See page 27.

vessel immersed in the one containing the boiling water, cannot be heated beyond that degree, and in fact does not quite reach it; how nevertheless a higher temperature may be obtained by putting into the water anything which may prevent its boiling at the accustomed degree, as for instance Common Salt, by using suitable quantities of which a bath may be obtained of any heat up to 228°, and how by means of Chloride of Calcium, the heat may be raised even up to 270°.—It is well however for those who have occasion to sojourn at considerable elevations to bear in mind, that the boiling point of water descends about 1° for every six hundred feet of vertical ascent, the temperature of a water-bath being limited accordingly, so that at the city of Quito, in Peru, it would not exceed 194°.—For a neat illustration of an ordinary water-bath, you must allow me to refer you to the small one commonly used for boiling milk, custards, and the like, which consists of an iron saucepan for boiling the water, with an inner porcelain or enamelled one for the article to be warmed.—Captain Warren's "Cooking Pot" (see Class III.) is a variety of the water-bath in which the inner pan is so tightly closed that a piece of meat placed in it without any water, does not get dry, but slowly cooks in its own juice, with a result said to be satisfactory.

In speaking of the amount of heat accumulated in STEAM, I mentioned the use made of it for industrial purposes as a conveyer of heat. Similarly, on the small scale of domestic operations, the water in a kettle or other vessel may be kept at 212° by a current of steam brought from a boiler by a supply tube. *Steaming* proper takes place when steam acts directly on the article to be cooked, as in the common Potato-steamer, which is sometimes added to Captain Warren's "Cooking Pot."

Another modification of the Water-bath which I should like to see introduced, would have for its object to utilise

in safety the principle of Papin's Digester. An iron outer pot would hold a saturated solution of Chloride of Calcium, heated as in the case of canistered provisions to 270°. The enamelled iron Digester made to plunge into this Bath might have a safety valve, but this would only be an extra precaution, for without becoming unwieldy it could be made stout enough to bear without danger the pressure of the steam produced at that temperature by its aqueous contents. This pressure would be under 45 lbs. to the square inch, or 3 atmospheres, exercising, as has been shown elsewhere, a disruptive pressure of only 2 atmospheres. The results aspired to would be —1ly, To dissolve the Gelatin of Bones, Cartilages &c. much more rapidly and completely than is done by ordinary boiling, without the drawbacks of submitting the Digester to an uncontrolled heat; namely, danger of explosion, and liability to the production of an empyreumatic flavor; 2ly, To place beyond doubt the destruction of cysts and noxious germs of every kind; 3ly, To turn to account any disintegrating and tender-making action exercised on the fibres of Meat, by a heat approaching to the critical temperature of 302° which renders Fibrin soluble; 4ly, To *stew* to perfection.

STEWING occupies an intermediary position between the *wet* and *dry* processes, or rather it unites in its comprehensive province the advantages of both. By augmenting the proportion of Water, as in the Irish Stew, you have an approximation to boiling, and on the contrary less Water and more Butter, or its equivalent, produce an approach to the dry process, in which Osmazome, supported by select auxiliaries, endows with the most appetising flavor, viands cooked to extreme tenderness. It is in fact in the various forms and denominations of Stewing that the *cordon bleu* finds scope for the highest aspirations of culinary art.

In FRYING, the gelatinous gravies disappear, and the fatty element reigns supreme. The consequence is that a much higher degree of temperature is reached, with a proportionately rapid effect. One must however be on one's guard against supposing that the frying medium, that is to say, the oil or butter, lard, dripping or other fatty matter in the frying-pan, boils every time that a hissing and crackling noise occurs on the introduction of the article to be fried, whether for instance it be a sole, a cutlet, or batter for a pancake. This hubbub is occasioned by the sudden transformation into vapour of the moisture contained in the article in question, and considering the probable temperature of the frying medium, no wonder that hot sputterings should often be thrown in the face of an ignorant or incautious cook. It is rather a matter for surprise that accidents of this description are not more frequent, for should the fire not be kept moderate, the liquid fats may rise to 500° before showing a first sign of change, by giving off offensive vapors. Even at the burning heat of 600°, they do not actually boil, though they simulate ebullition by decomposing, with a rapid evolution of gaseous hydro-carbons. Considering that only 17° more are required to melt Lead, it is obvious that the frying-pan is not to be trifled with.—There are culinary processes which children may be encouraged to imitate in play, but frying is not one of them.—There is another point of view under which the frying-pan requires looking after ; namely, the tendency of fatty substances when exposed for a long time to a high temperature, to give rise to the sharp volatile product which has been described under the name of Acrolein, and which if allowed to enter our alimentary system, makes manifest its presence by the sensation known as heart-burn. It is obvious that to escape this tendency, care must be had not to use fats that are rancid

to begin with, to renovate entirely the supply as often as may be needed, and each time that the dripping is poured out of the pan, to well cleanse the latter.

In order to avoid the fattiness which is a chief drawback of fried articles, and makes them unfit for some stomachs, Cutlets are sometimes wrapped in paper before being consigned to the frying-pan, when they are said to be *en papillotte.* There is of course a certain waste of dripping, and the surface of the meat does not acquire so piquant a browning, but it becomes tender and savory. The question naturally arises,—might not these latter results be obtained in an eminent degree by enclosing say a Rump-Steak, between two shallow pans, tightly adjusted face to face, and which might be kept for the required time at a high temperature? The ingenuity of Captain Warren has in some measure supplied an affirmative answer in his patent Bachelor's Broiler.

BROILING or GRILLING is a still more violent process than Frying, the heat of a clear fire acting directly and powerfully on the meat. It favors in a high degree the concentration of the juices and the formation of Osmazome, hence the relish with which Chops and Steaks done this way are eaten by appetites that would flag without such a stimulus. On the other hand, Acrolein and other acrid emanations are but too easily engendered by the fierce heat impinging on the fatty portions of the meat, which is moreover exposed to similar products rising from the dripping consumed in the fire. An attempt has been made to diminish this wasteful mischief by using Gridirons of which the bars are grooved, forming small channels by which a portion of the melted fat is conducted to a reservoir at the handle. Its rescue from the fire is more effective in the American appliance recently introduced, which resembles a small Frying-Pan of enamelled iron, of which the bottom bulges up, and

is punched with a number of raised holes for allowing the direct action of the fire on the meat. At all events much depends upon the cook whose cleverness and experience are sharply taxed in this short but trying operation. The Tongs introduced as a substitute for the Fork which used to prick the chop in turning it, and let out some of its juice, are another small step in the right direction. As for the silvered gridiron, its best recommendation is that it favours cleanliness by showing up any adherent particles of burnt fat.

Two Gridirons attached face to face, so as to hold steaks or the like between them, form *Toasters* which hooked in front of an open fire, and turned when required, do the work of a Gridiron, without the inconveniences of exposure to smoke from any remnant of imperfectly carbonized Coal, and fumes from the burning of the dripping. The latter may indeed be collected as it trickles from the Meat, in an appended pan or trough.

Less economical in this latter respect is the practice so often adopted by those who can ill afford it, of toasting meat on a fork before the fire. Some 30 years ago when the Laborer's Friend Society established its Model Lodging Houses, one of the chief attractions of these lay in the privilege enjoyed by the artisan inmates of toasting their steak, small but prime, at a broad blazing and scorching open fire. They enjoyed the operation amazingly, and it would have been invidious to institute a comparison between the quantity of toasted meat that came to their bread, and the respective amounts paid by them to the butcher, and by the Society to the Coal merchant,—amounts which by a judicious clubbing of resources might have afforded to every man a copious, as well as wholesome and savory repast.

ROASTING may be said to be Toasting on a grand

scale, but it acquires through these very dimensions a different relation to the fire employed, to say nothing of the economical paraphernalia with which it is surrounded ;—a Dutch Oven for concentrating the heat, and thereby saving the fuel ; the Dripping-Pan with its convenient Well, and appropriate Basting Spoon ; and above all, the automatic machinery which supplies and regulates the rotatory motion. There was a time when a little *turn-spit* dog performed the tedious and tantalising task, which was an improvement on the employment of poor boys mentioned by Aubrey. Then mechanical science established a "Roasting Jack," in which a heavy weight, laboriously wound up by means of complex pulleys, served to turn for the whole of the time required, by means of an endless chain, the suspended end of the horizontal spit. It was a highly successful piece of machinery, but kitchen-maids disliked the labor of winding it up, and this accounts for the favor which greeted the introduction in many establishments of the "Smoke Jack." Here the current of hot air rushing up the chimney was utilised as motive power by means of a fan-wheel. It was an ingenious and truly scientific contrivance, which I remember seeing in operation about 70 years ago, and it was certainly creditable to those early times of culinary progress, though it had the drawback of being liable to get out of order, and of requiring a greater fire than would at all times be necessary.—It was a bold innovation to dispense with the Spit altogether for small joints, and to substitute a vertical for a horizontal axis of rotation by means of the "Bottle Jack." Fortunately for the health and temper of our cooks, open fires are on the wane, and Roasting is fast yielding the palm to the sister process which still remains to be discussed.

Baking has long been known among the Working Class as an advantageous mode of cooking a Sunday

joint with a substratum of potatoes or Yorkshire pudding; but among the rich a prejudice prevailed against it till the desire to economize fuel, as well as to vary the applications of the heat produced, led to the substitution of Kitcheners, with well regulated Ovens, and handy Hot-plates, for the fiercely radiating and less easily manageable open Ranges. When I speak of economy of fuel, I assume that the Kitchener is not only intelligently constructed, but also intelligently worked; for I have known of certain cooks who having got thoroughly tempered to the scorching fire, pertinaciously advocated its advantages, and managed on the other hand by the manipulation of the valves to convert the silent Kitchener into a roaring furnace, that devoured scuttleful after scuttleful of coals with astonishing rapidity.

More difficult to overcome than this touch of culinary prejudice, was the apprehension that a baked article, whether a joint or a fowl, would be less appetising outside, and less savory inside, than if it were *roasted.* With some persons this prejudice still exists, and in reference to certain viands, especially those which require much basting, it may be reasonable enough. The plan of making ovens with an arrangement for carrying off the steam if desired, and with it any Acrolein or fatty acids fortuitously produced, seems a judicious compromise. At all events it is now daily proved that joints of ordinary dimensions can, as in Germany, be baked to the satisfaction of every reasonable connoisseur.

In referring you to Class III. for select examples of the improvements wrought by Science in the paraphernalia of the Kitchen, you will recognise with pleasure, a desire to give prominence to things aiming at the health and comfort of the million. This is obviously the right way of doing homage to the memory of the eminent Sanitarian, who loved to mingle in the precepts of Mili-

tary Hygiene, those devices which might benefit mankind at large. A spirit of broad philanthropy pervades, as far as practical, the whole of this Museum. There is comparatively little scope for its display in the scientific information to which this preliminary Section is devoted, but it will be amply manifested in the other portions of the Food Department. You will be pleased to find that not only is prominence given to the alimentary articles best adapted to humble means in this country, but that this philanthropic survey will embrace with expansive ken, the food resources best suited for races that dwell in widely different climes, and you will notice with satisfaction how much a study, too often debased by sensual selfishness, is enhanced in interest by being made an instrument of beneficence.

APPENDIX No. I.

(*See page* 5.)

CONSTITUENTS OF THE HUMAN BODY.

Arranged according to quantity, as given in Prof. Church's Handbook to the Food Museum at Bethnal Green.

A. PROXIMATE.

	lbs.	ozs.	grs.
1. Water	109	0	0
2. Fibrin and similar substances	15	10	0
3. Phosphate of Lime	8	12	0
4. Fat	4	8	0
5. Ossein	4	7	350
6. Keratin and similar substances	4	2	0
7. Cartilagin	1	8	0
8. Hæmoglobin	1	8	0
9. Albumen	1	1	0
10. Carbonate of Lime	1	0	350
11. Kephalin and similar substances	0	13	0
12. Fluoride of Calcium	0	7	175
13. Phosphate of Magnesia	0	7	0
14. Chloride of Sodium	0	7	0
15. Cholesterin, Inosite and Glycogen	0	3	0
16. Sulphate, Phosphate and Organic Salts of Sodium	0	2	107
17. Sulphate, Phosphate and Chloride of Potassium	0	1	300
18. Silica	0	0	30
Total—very nearly	154	3	0

B. ULTIMATE.

	lbs.	ozs.	grs.
1. Oxygen (1290 cu. ft.)	109	2	335
2. Carbon	18	11	150
3. Hydrogen (2690 cu. ft.) . . .	14	3	150
4. Nitrogen (66 cu. ft.) . . .	4	14	0
5. Phosphorus	1	12	25
6. Sulphur	0	8	0
7. Chlorine (1 cu. ft. 772 cu. inches) .	0	4	150
8. Fluorine (probably 2 cu. ft. 510 cu. inches)	0	3	300
9. Silicon	0	0	14
10. Calcium	3	13	190
11. Potassium	0	3	340
12. Sodium	0	3	217
13. Magnesium	0	2	250
14. Iron	0	0	65
15 and 16. Manganese and Copper .		traces	
Total—very nearly	154	3	0

PERCENTAGE ANALYSES OF THE HUMAN BODY.

Calculated from the foregoing Tables, and arranged in classified order.

A. PROXIMATE ANALYSIS.

ORGANIC.

I. Nitrogenous.

a. Albuminoids.

Albumen	·689	
Hæmoglobin . . .	·973	
Fibrin, &c. . . .	10·134	
Kephalin, &c. . . .	·527	
		12·323

b. Gelatinoids.

Ossein	2·911	
Keratin, &c. . . .	2·675	
Cartilagin (Chondrin) . .	·973	
		6·559
		18 882

II. Non-nitrogenous. (*Carbonaceous.*)

a. Stearoids. (Fats) . . .	2·918
b. Saccharoids. . . .	
Inosite	·121
Glycogen	
Cholesterin (Carbonaceous but not Saccharoidal) .	
	3·039

INORGANIC.

I. Liquid. (Water) . . .			70·69
II. Solid.			
a. Potassium.			
Chloride, Sulphate, Phosphate .		·0683	
b. Sodium.			
Chloride . . .	·284	·375	
Sulphate, Phosphate, &c.	·091		
c. Calcium.			
Phosphate . .	5·675	6·655	
Carbonate . .	·681		
Fluoride . .	·299		
d. Magnesium.			
Phosphate.		·284	
e. Silica.		·0027	
			7·385

SUMMARY.

A. ORGANIC.

I. Nitrogenous.		
Albuminoids . . .	12·323	
Gelatinoids . . .	6·559	
		18·882
II. Non-nitrogenous.		
Stearoids . . .	2·918	
Saccharoids . . .	·121	
		3·039

B. INORGANIC.

I. Liquid (Water)	70·690
II. Solid (Mineral Matter or Ash) .	7·385
Total	99·996

Or Organic Matter 21·921 + Inorganic Matter 78·075 = 99·996
Or Liquid 70·690 + Solid 29·306 = 99·996

B. ULTIMATE ANALYSIS.

I. Gases.

1. Oxygen	70·805	
2. Hydrogen	9·216	
3. Nitrogen	3·161	
4. Chlorine	·176	
5. Fluorine	·149	
		83·507

II. Solids.

a. Non-metallic.

6. Carbon	12·134	
7. Phosphorus	1·137	
8. Sulphur	·324	
9. Silicon	·0013	
		13·596

b. Metallic.

10. Potassium	·153	
11. Sodium	·142	
12. Calcium	2·492	
13. Magnesium	·105	
14. Iron, Traces of Lithium, Manganese, Copper and Lead	·006	
		2·898
		100·001

SUMMARY.

I. Gases		83·507
II. Solids		
Non-metallic .	13·596	
Metallic .	2·898	
		16·494
Total		100·001

APPENDIX No. II.

(*See page* 9.)

SYNOPSIS OF THE MOST IMPORTANT MODERN CLASSIFICATIONS OF FOOD.

No. I.

Arrangement adopted for the Food Collection at the South Kensington Museum by DR. EDWIN LANKESTER, *in* 1859. *See the Guide to the Food Collection*, 1860.

Class I.—Alimentary or Necessary Food.

Group 1.—*Mineral.*
a. Water. *b.* Salt. *c.* Ashes of Plants and Animals.

Group 2.—*Carbonaceous* or *Respiratory* (Heat-giving).
a. Starch. *b.* Sugar. *c.* Fat.

Group 3.—*Nitrogenous* or *Nutritious* (Flesh-forming).
a. Albumen. *b.* Fibrine. *c.* Caseine.

Class II.—Medicinal or Auxiliary Food.

Group 1.—*Stimulants.*
a. Alcohol. *b.* Volatile Oils.

Group 2.—*Alteratives.*
a. Acids. *b.* Alkaloids.

Group 3.—*Narcotics.*
a. Tobacco. *b.* Hemp. *c.* Opium.

Class III.—Accessory Food.

a. Cellulose. *b.* Gum. *c.* Gelatine.

No. II.

The following is the arrangement given in the "GUIDE TO THE FOOD COLLECTION," *published in July* 1872, *after the transfer from the South Kensington Museum to its Bethnal Green Branch.*

Class I.—Alimentary or Necessary.

Group 1.—*Mineral Substances.*

Exs. Water, Common Salt, Ashes of Plants and Animals.

Group 2.—*Non-nitrogenous* or *Force-producing Substances;* incapable of forming flesh or muscle.

Exs. Sago, Arrowroot. (Amylaceous.)
Sugar, Figs, Dates. (Saccharine.)
Animal and Vegetable Fats and Oils. (Oleaginous.)

Group 3.—*Nitrogenous Substances;* capable of producing both flesh and muscle.

Exs. Eggs. (Albuminous.)
Wheat, Flesh. (Fibrinous.)
Peas, Cheese. (Caseinous.)

Class II.—Medicinal or Auxiliary.

Group 1.—*Containing Alcohol.*

Exs. Beers, Wines, Spirits.

Group 2.—*Containing Volatile Oils.*

Exs. Spices and Condiments, as Cloves, Nutmegs, Pepper, Horse-radish, &c.

Group 3.—*Containing Acids.*

Exs. Apples, Oranges, Rhubarb, Vinegar.

Group 4.—*Containing Alkaloids,* which act on the nervous system as stimulants or sedatives.

Exs. Tea, Coffee, Cocoa, Tobacco, Hemp, Opium.

No. III.

The following is the Classification of the above Collection adopted under the guidance of Prof. A. H. Church, 1876.

Class I.—Nutrients.

Division 1.—*Incombustible Compounds.*

Group 1.—Water.

Group 2.—Salts or Mineral Matter, such as Common Salt and Phosphate of Lime.

Division 2.—*Combustible Compounds.*

Group 3.—Carbon Compounds, Heat-givers, Force-producers; as Starch, Sugar, Fat.

Appendix. Gum, Mucilage, Pectose, Cellulose.

Group 4.—Nitrogen Compounds, Flesh-formers, viz. Fibrin, Albumen and Casein.

Appendix. Ossein, Gelatin, Cartilage and Chondrin, Keratin and Elastin.

Class II.—Food Adjuncts.

Group 1.—Alcohol as in Beers, Wines and Spirits.

Group 2.—Volatile or Essential Oils, and other odorous and aromatic compounds, in Condiments like Mustard and Pepper, and in Spices like Ginger and Cloves.

Group 3.—Acids, as Citric, Malic, Tartaric, Oxalic, and Acetic.

Group 4.—Alkaloids, as Caffeine, Theobromine and Nicotine.

No. IV.

From "A Manual of Practical Hygiene," by Dr. Edmund A. Parkes ; *5th edition, by Dr. F. de Chaumont*, 1878.

Class I.—Nitrogenous Aliments.

Albuminates. Blood-fibrine, Muscle-fibrine, Myosin, Vegetable-fibrine ; Albumen ; Casein ; Globulin.

Other Nitrogenous bodies, as Gelatine, Chondrin, Keratin or Elastin.

Class II.—Animal and Vegetable Fats, Wax, &c.

Class III.—Starchy and Saccharine Substances. (*Carbo-hydrates.*)

Including Lactin and Cellulose, with their allies or derivatives. (Dextrin, Pectin.)

Class IV.—Salts and Water.

Mention is made of "*Accessory Foods*," such as Condiments, together with Tea, Coffee, Alcohol, &c.]

No. V.

From "Lessons in Elementary Physiology," by Prof. Huxley.

Vital Food Stuffs. *i.e.* Produced by the agency of Life.

I. Proteids.

Glutin, Albumin, Fibrin, Casein.
Outlying Members. Gelatin and Chondrin.

Essential Food Stuffs.

II. Fats.

III. Amyloids.

Starch, Dextrin, Sugar, Gum.

Accessory Food Stuffs.

IV. Minerals.

Water and Salts ; perhaps Oxygen.

The Author deprecates the term "Tissue Formers" as applied to the Proteids, and the term "Heat Producers" as applied to Fats and Amyloids.

No. VI.

From "Handbook of Physiology," by Dr. Kirkes, *edited by W. M. Baker.*

"The usual and more necessary kinds of Food" may be arranged thus :—

I. Nitrogenous. (*Nutritive or Plastic.*)

Albumen, Casein, Gelatin, and their allies.

II. Non-nitrogenous. (*Calorifacient or Respiratory.*)

1. Starch, Sugar, Alcohol, and their allies.
2. Oils and Fats.
3. Minerals, or Saline Matters.
4. Water.

No. VII.

From "Principles of Human Physiology," by Dr. W. B. Carpenter, *edited by Dr. Hy. Power.*

Organic Aliments.

Respiratory	Class 1.	*Saccharine.* Sugars, Gums, Starches.
	Class 2.	*Oleaginous.*
Histogenetic	Class 3.	*Albuminous.* Including Gelatine.

Inorganic Aliments.

Class 4.

Miscellaneous, as Acids, Pectin, &c.

No. VIII.

From "A Treatise on Food and Dietetics," *by* Dr. F. W. Pavey.

ORGANIC FOOD.

I. Nitrogenised Principles, *mainly Histogenetic or Tissue-forming.*

a. Albuminous Group.
b. Gelatinous Group.

II. Non-nitrogenised Principles, *mainly Calorifacient.*

a. Fats or Hydro-carbons.
b. Carbo-hydrates. Starch, Sugar, &c.
c. Principles such as Alcohol, Pectin, Vegetable Acids, &c.

INORGANIC FOOD.

a. Water.
b. Saline Matter.

APPENDIX No. III.

(*See page* 75.)

Specific Gravity of some saline solutions from sea-water to saturation.

Water of the Atlantic Ocean . . .	1·02
Brine at the salt-works of Reichenhall near Salzburg, after concentration . .	1·14
Water of the Dead Sea	1·186
Saturated solution of Common Salt . .	1·205

Total percentage of Salts in various sea-waters.

(*From "The Chemistry of Common Life."*)

Black Sea (Crimea)	·18
Caspian Sea	.63
Sea of Azof	1·19
Baltic Sea	1·77
Mediterranean (at Venice)	2·91
German Ocean (Havre)	3·27
Mediterranean (at Marseilles) . . .	4·07
Dead Sea	24·05

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